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PACIFIC SCIENCE

A QUARTERLY DEVOTED TO THE BIOLOGICAL AND PHYSICAL SCIENCES OF THE PACIFIC REGION

IN THIS ISSUE: Strasburg — *Blennioid Fishes of Hawaii* • Ballard — *Ferns in* Oceanic Sketches • Ochiai and Mitani — *Japanese Fishes of Genus* Malthopsis • Zimmerman — *Catalogue of* Elytrurus *(Coleoptera)* • Okada and Suzuki — *Taxonomic Considerations of* Polyipnus • Matthews — *Fertilization in Hermit Crabs* • Sakaguti and Jameson — *New Fleas From Japan* • Morris — *Clasping Mechanism of Cottid Fish* • Banner — *Alpheid Shrimp of the Marianas*

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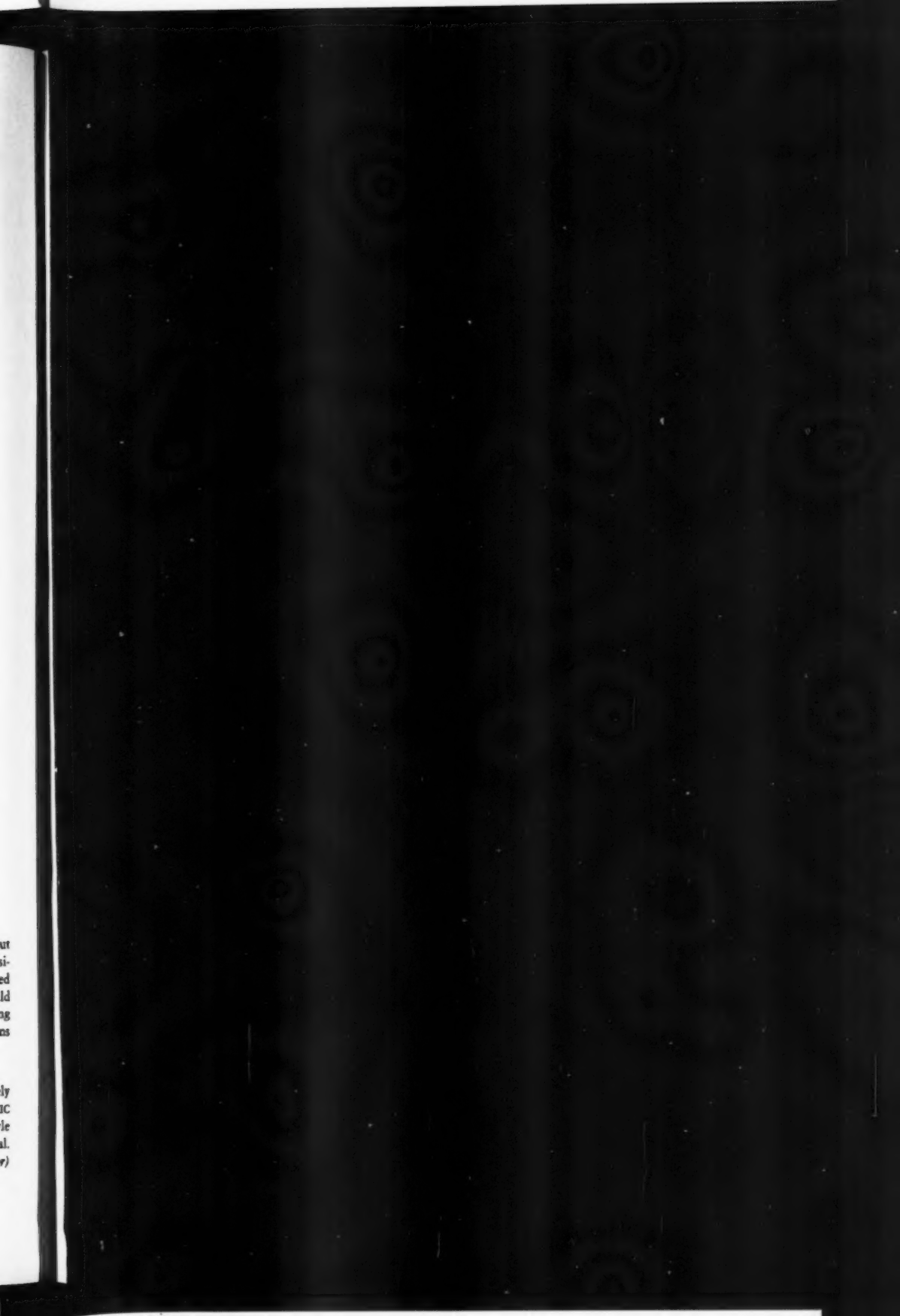
(Continued on inside back cover)



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Notes on the Blennioid Fishes of Hawaii with Descriptions of Two New Species

DONALD W. STRASBURG[1]

ALTHOUGH NEARLY EVERY REPORT on the Hawaiian inshore fishes alludes to the blennies, the Hawaiian members of this group have never been reviewed in their entirety. Jordan and Evermann (1905) discuss and figure most of the common forms, while Jordan and Seale (1906) and Fowler and coauthors (1901, 1922, 1925, 1928, 1949) present supplemental data. Unfortunately the taxonomy employed in the above reports is sometimes inaccurate because of the close resemblance between Hawaiian blennies and those of other areas, and in a few instances it errs because of a species being based on a larval or sexual form. There are overall problems of a lack of adequate keys and of generic names not being up to date.

This paper was prepared with a three-fold purpose. It attempts to clarify certain nomenclatorial problems, it provides a key and a description for the identification of each Hawaiian species, and it reports two hitherto undescribed forms as new, along with a new record of a previously known species. The geographical scope of this study includes the high or windward Hawaiian Islands, the leeward islets and shoals extending from Niihau northwest to Midway Island, Midway Island itself, and Johnston Island. Specimens have been taken from numerous islands in this assemblage, with the major collecting emphasis being on Oahu, in the windward Hawaiian chain. Where synonymies are given they refer only to Hawaiian records unless otherwise noted.

[1] United States Fish and Wildlife Service, Honolulu. Work done at Duke University, Durham, N. C. Manuscript received May 23, 1955.

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I am greatly indebted for assistance received from numerous individuals and institutions. Dr. William A. Gosline and other staff members of the University of Hawaii aided me in collecting many of the specimens examined. The Museum of Comparative Zoology at Harvard College sent certain early collections of Hawaiian blennies; Dr. J. L. B. Smith loaned a South African specimen of *Entomacrodus;* and Dr. Itiro Tomiyama supplied specimens of several Japanese blennies. Drs. N. B. Marshall and Gilbert P. Whitley, of the British and Australian Museums respectively, examined type material unavailable to me. I am grateful for permission to examine specimens and use various facilities at the United States National Museum, the American Museum of Natural History, the Bernice P. Bishop Museum, the University of Hawaii, the Pacific Oceanic Fishery Investigations (U. S. Fish and Wildlife Service, Honolulu), and the Territorial Division of Fish and Game (Honolulu). In this report these institutions are referred to as follows: USNM, AMNH, BPBM, UH, POFI, and DFG. The

Museum of Comparative Zoology at Harvard College is abbreviated as MCZ. Mr. James K. Park of Honolulu prepared Figure 2.

METHODS

The Hawaiian blennioid fishes include representatives of the families Blenniidae and Tripterygiidae. As pointed out by Clark Hubbs (1952: 50), these families are readily distinguishable by the presence of scales in the Tripterygiidae and by their universal absence in the Blenniidae (except in *Neoclinus*, which does not occur in Hawaii). In addition to the presence of scales, the three dorsal fins and bright red coloration render the single Hawaiian tripterygiid a readily identifiable form.

Norman's analysis of the genera (1943), supplemented by Schultz's definition of *Runula* (1950) and Strasburg and Schultz's of *Cirripectus* and *Exallias* (1953), constitutes the basis for generic subdivision of the Hawaiian Blenniidae. The need for dividing certain heterogeneous genera such as *Istiblennius* has been implied by Norman (*op. cit.*), but it is felt that such separation should be made in monographic treatments and not in a faunal report. The Hawaiian blennies can be subdivided into the subfamilies Blenniinae and Salariinae as shown by Norman (*op. cit.*), but it appears that his Ophioblenniinae may represent only larval forms.

In the following key considerable use has been made of meristic characters, and the methods used in counting certain structures need explanation. Each fin ray with a separate and distinct base was counted as one, and those rays split to a single base were also counted as one ray. Spines and soft rays are sometimes difficult to distinguish in the Hawaiian blennies, but can often be differentiated when the fin is held before a strong light, or by removing the membrane from one side of the fin. In general, the spines are soft and flexible but rather more slender than articulated rays. In certain genera the dorsal fin membrane is notched between the spinous and soft-rayed portions, and the minute last dorsal spine occurs at the base of this notch. In those genera having the dorsal fin entire the last dorsal spine is about the same size as the penultimate one.

The anal fin of Hawaiian blennies is composed of two short, weak spines (only one spine in the tripterygiids) followed by a series of longer soft rays. Aside from their length it is practically impossible to distinguish anal spines from rays without dissection and staining, and the problem is further complicated in female blenniids where the first spine becomes embedded in genital tissue with growth. In adult male *Cirripectus* and *Exallias* each anal spine is enclosed in a mass of spongy tissue, the presence of which facilitates sex determination.

The methods employed by Strasburg and Schultz (1953: 129) have been used for counting head cirri. A nuchal cirrus was counted as one if it had a single base, cirri with distal or basal branches thus being enumerated as one. The degree and type of branching of supraorbital cirri was found to be useful in distinguishing species of *Cirripectus*, and the morphology of these structures is discussed in the key and species diagnoses.

An important characteristic of some blenniids is their possession of canine teeth in addition to numerous small incisors. Canines range in size from short stubs in *Entomacrodus* to large fangs in *Runula*, but are lacking in *Istiblennius zebra* and *Exallias*. When present, canines occur posteriorly in the jaws and mesial to the incisors.

Many Hawaiian blennies have relatively large larvae which are considerably different from the adults. In a few cases such larvae have been the basis for the erection of genera and species, and only recently (Chapman, in de Beaufort and Chapman, 1951: 249–254) have they been recognized as larval forms. Larvae are readily distinguished from juveniles by their glassy transparency when alive and their nearly uniform straw or white coloration

in preservative. Identification of larvae usually cannot be made with the following key.

DUBIOUS RECORDS

Jordan and Evermann (1905: 5, 7, 10, 23, 497), Fowler (1928: 432), (1938: 300), and others have listed *Hypsoblennius sordidus* (Bennett) as a valid Hawaiian species. Fowler (1901: 517; 1922: 84; 1928: 428; 1938: 300) also records *Aspidontus filamentosus* (Valenciennes) from Hawaii but later (1949: 146) changes the name of his specimen to *Aspidontus taeniatus* Quoy and Gaimard. Fowler (1928: 442; 1938: 301) lists Hawaiian specimens of *Istiblennius lineatus* (Valenciennes) as being in the United States National Museum, but a thorough search by the writer did not reveal the specimens there. Günther's Hawaiian record of *Hypsoblennius brevipinnis* (1861: 226; 1877: 194) is probably a geographical error as was pointed out by Jordan and Evermann (1905: 504), although the species is not a synonym of *Exallias brevis* as indicated by the latter authors (*ibid.*). Jordan and Evermann's listing of *Scartichthys sauritus* (1905: 17), which would be a blenny, is a misspelling based upon Fowler's earlier record (1901: 511) of *Scarichthys auritus*, a parrot fish.

Since none of the above species has been taken in the writer's five years of collecting in Hawaii, it is possible that records of their Hawaiian occurrence are invalid. They are not considered further in this report, but erroneous records of other species are listed under the appropriate synonymy.

KEY TO THE HAWAIIAN BLENNIOID FISHES

1a. Body covered with scales; three separate dorsal fins, the anterior two composed of spines; living specimens red or brownish red, males with black heads (family Tripterygiidae) . . . . . **Tripterygion atriceps**

1b. Body without scales; dorsal fin composed of flexible spines anteriorly and soft rays posteriorly, the two regions often separated by a notch in the connecting membrane, and appearing as separate fins (family Blenniidae) 2

2a. A transverse fringe of from 25 to 45 cirri across the nape 3

2b. No fringe of cirri across nape; if cirri occur on nape they total four or less . . 6

3a. Dorsal rays XII, 13 (rarely XII, 12); no canines on dentary; teeth in lower jaw more or less rigidly implanted, those in upper jaw freely movable; lower teeth about twice as broad and half as numerous as those in upper jaw; a pair of stubby tentacles on each side of chin; with numerous small dark spots on pale background, spots sometimes arranged in clusters which may align to form vertical bars . . . . . **Exallias brevis**

3b. Dorsal rays XII, 14 to 16 (very rarely 13); a short stout canine posteriorly on dentary; teeth in both jaws freely movable, of approximately equal width and number; no tentacles on chin; ground color dark, unmarked, or with light or dark spots 4

4a. An elongate dark spot, about size of pupil, behind eye; dorsal rays XII, 16 (rarely 15); anal rays usually II, 17; upper part of membrane between anterior dorsal spines dusky, not abruptly pale or transparent; bases of upper pectoral rays notably darker than bases of lower rays; head and trunk rosy or reddish brown, tail dark brown, frequently with irregular olive or tan blotches; head and body usually covered with scattered white dots . . . . . **Cirripectus obscurus**

4b. No dark spot behind eye; dorsal rays XII, 14 or 15 (very rarely 16); anal rays II, 15 or 16 (rarely 17); anterior dorsal fin membrane dusky basally, abruptly pale or transparent (red in life) distally; base of upper and lower pectoral rays about same shade 5

5a. Body dark brown, marked with small

white or yellowish dots arranged in three to five lengthwise rows, sometimes also marked with tiny black dots; supraorbital cirrus slender, normally unbranched, if branched, filaments (not more than 5) arise from a central axis; dorsal rays usually XII, 15; anal rays usually II, 16; nuchal cirri totaling 25 to 32, usually 26 to 30; membranous attachment of last dorsal ray to caudal peduncle ending directly above flexure marking caudal base; line separating dusky and pale portions of dorsal fin running from base of first spine to tip of about sixth spine . . . . . **Cirripectus lineopunctatus,** n. sp.

5b. Body uniform tan to brownish black, unmarked; supraorbital cirrus multifid, 4–11 (usually 5–8) branches arising from a broad base; dorsal rays XII, 14; anal rays II, 15; nuchal cirri totaling 31 to 43, usually 32 to 40; membranous attachment of last dorsal ray to caudal peduncle ending about one pupil diameter, or more, posterior to flexure marking caudal fin base; line separating dusky and pale portions of dorsal fin running from base of first spine to tips of anterior soft rays . . . . . **Cirripectus variolosus**

6a. Teeth, excluding canines, loosely set in gums and freely movable (only in upper jaw of *Ecsenius*); gill opening large, elongate, extending beyond base of pectoral fin both dorsally and ventrally 7

6b. Teeth in both jaws firmly attached, practically immovable; gill opening restricted to a narrow slit commencing above pectoral base and running ventrally to level of middle pectoral rays . **10**

7a. A cirrus present over each eye; dorsal fin with deep notch between spinous and soft-rayed portions; more than 100 incisiform teeth in lower jaw, freely movable; dorsal spines XIII (very rarely XII); a single multifid cirrus on each anterior nostril 8

7b. No supraorbital cirrus; dorsal fin entire; not more than 50 incisiform teeth in lower jaw, firmly attached, only slightly movable; dorsal rays XII, 16–18; anal rays II, 17–20; two cirri on each anterior nostril, the upper one longer and simple, the lower one sometimes bifid . . . . . **Ecsenius hawaiiensis**

8a. A pair of cirri present on each side of nape, the mesial one larger and usually multifid, the lateral one slender and simple or occasionally bifid (lateral cirrus sometimes lacking in juveniles); supraorbital cirrus multifid; upper lip crenulate; soft dorsal rays 14–16; anal rays II, 15–17 . . . . . **Entomacrodus marmoratus**

8b. No cirri on nape; supraorbital cirrus simple; upper lip smooth; soft dorsal rays 18–23; anal rays II, 19–24 9

9a. Adults and juveniles over 50 mm. in length with a median membranous crest on head, and with last soft dorsal ray attached to uppermost caudal rays by a membrane; no canines on dentary; dorsal rays usually XIII, 21–23, most commonly XIII, 22; anal rays II, 22 or 23; body tan to bluish black, frequently marked with light vertical bars; fins nearly uniformly dusky . . . . . **Istiblennius zebra**

9b. No crest on head; last soft dorsal ray free from caudal fin; a short canine posteriorly on dentary; dorsal rays XIII, 19–21, usually XIII, 19 or 20; anal rays II, 19–21; body tan, variously covered with light and dark spots; vertical fins spotted . . . . . **Istiblennius gibbifrons**

10a. Trunk and tail uniform deep brownish black or jet black; head and dorsal fin of males dark gray and marked with black lines or spots; dorsal and anal fins united to caudal by membranes (except in small juveniles); length rarely greater than 1 inch . . . . . **Enchelyurus brunneolus**

10b. Trunk and tail not uniformly colored but marked with dark stripes, lines, or bars on a lighter background; dorsal and anal fins not united to caudal; adult length 2–4 inches 11

11a. Isthmus and throat pale, crossed by 5 or 6 dark V-shaped lines which are continued on cheeks; a dark spot, about size of eye, behind eye; body tan or yellowish, marked with about 11 oblique and vertical dark bars; a stout canine on each side of upper and lower jaws; pectoral rays 13 . . . . . **Omobranchus elongatus**

11b. Isthmus and throat pale, not crossed by dark lines; no dark spot behind eye; color pattern consisting of a dark lengthwise stripe, or stripes, against a lighter background; canines limited to lower jaw; pectoral rays 12 12

12a. A pair of black-edged blue stripes running length of body but not extending onto caudal fin; upper stripe narrow, passing dorsal to eye; lower stripe broad, passing ventral to eye; rest of body gray (brick-red in life); anal rays II, 32 or 33 . . . . . **Runula ewaensis**

12b. No black-edged blue stripes present; upper half of head and body brown, lower half abruptly white; brown area divided into two lengthwise stripes by a narrow white line running from snout across upper edge of eye to caudal peduncle; lower brown stripe frequently bearing dark blotches along its length; anal rays II, 29 or 30 . . . . . **Runula goslinei,** n. sp.

Family TRIPTERYGIIDAE

Genus TRIPTERYGION Risso

Tripterygion Risso (1826: 241). Type of genus, *Tripterygion nasus* Risso.

Tripterygion atriceps Jenkins

Tripterygion atriceps Jenkins (1903: 505, type locality Honolulu).

Enneapterygius atriceps. Jordan and Evermann (1905: 19, 27, 496); Jordan and Seale (1906: 416); Fowler (1922: 84); Fowler and Ball (1925: 28); Pietschmann (1930: 20).

Enneapterygius atripes Jordan and Jordan (1922: 82).

Enneapterygius hemimelas. Fowler and Ball (1925: 28); Fowler (1927*a:* 29; 1928: 427; 1934: 445; 1938: 300; 1949: 145, in part); Pietschmann (1938: 44); Tinker (1944: 341); Edmondson (1946: 352).

This diminutive blenny has frequently been considered synonymous with the Samoan *T. hemimelas* Kner and Steindachner (1866: 371) to which it is closely related. Although the type of *hemimelas* was not seen, 20 specimens from Samoa and the neighboring islands of Tau and Rose were examined, and meristic data from these specimens and Hawaiian *atriceps* are presented in Table 1. These data may be summarized by saying that *atriceps* averages about one ray more than *hemimelas* for the anal and second and third dorsal fins, and that it also has more notched scales in the posterior lateral line. Males of both species differ from females in that their heads are black whereas those of females are relatively pale. Male *atriceps* have dark lips and their bodies are marked with a series of 9–14 dusky vertical bars which are frequently interrupted on the mid-sides and are sometimes fused to form about 6 bars dorsally. In male *hemimelas* the upper lip is dusky anteriorly and pale posteriorly, and the dusky body pigmentation is localized as a very broad vertical bar beneath the soft dorsal and another across the caudal peduncle. Female *atriceps* have the barred pattern of males but lack the black head pigmentation; female *hemimelas* are marked with only a few scattered dark pigment spots. In light of these differences *T. atriceps* is regarded as distinct from *T. hemimelas.*

Chapman and Schultz (1952: 528), believing *atriceps* and *hemimelas* synonymous, reported a specimen of *hemimelas* from a barge

hauled from Guam to Pearl Harbor and there placed in drydock. This specimen (USNM No. 112290) was examined and found to be neither *atriceps* nor the Guamanian form (undescribed, and here based on USNM No. 123931). The barge specimen appeared to be most similar to typical Rose Island and Samoan *hemimelas*, and it is possible that this species is now established in Hawaii. In view of our limited knowledge of this barge's itinerary it is perhaps unwise to ascribe specific locales to specimens taken from it (cf. *Ecsenius hawaiiensis*).

T. atriceps is apparently an endemic Hawaiian blenny. It is abundant but seldom seen alive because of its habit of secreting itself in crevices in shallow reefs. Specimens may be obtained by splitting masses of coral rock or by the use of rotenone.

MATERIAL EXAMINED: *T. atriceps*—holotype and 6 paratypes at USNM; 15 Oahu at UH; 5 Oahu and 21 Hawaii in writer's collection. *T. hemimelas*—1 Apia, 8 Tutuila, 5 Rose Is., 6 Tau Is. at USNM.

TABLE 1
COUNTS MADE ON SPECIES OF *Tripterygion*

		T. atriceps (HAWAII)	*T. hemimelas* (SAMOAN AREA)
Dorsal fin	III	48	16
	XII		2
	XIII	4	14
	XIV	41	
	XV	3	
	8	4	
	9	23	14
	10	21	2
Anal fin	I	48	18
	16		2
	17		9
	18	5	7
	19	35	
	20	8	
Pectoral fin (both sides counted)	14	1	3
	15	27	20
	16	24	13
Pore-bearing scales in anterior lateral line	16	3	1
	17		6
	18	11	1
	19	9	4
	20	4	
Notched scales in posterior lateral line	16	3	3
	17	3	4
	18	9	
	19	7	1
	20	2	

Family BLENNIIDAE

Genus EXALLIAS Jordan and Evermann

Exallias Jordan and Evermann (1905: 503). Type of genus, *Salarias brevis* Kner.
Gloriella Schultz (1941: 17), based on Ternate material.
Leoblennius Reid (1943: 382).

Exallias brevis (Kner)

Salarias brevis Kner (1868*a:* 29; 1868*b:* 334, pl. 6, fig. 18, type locality Savay, Samoa); Fowler (1901: 518); Jenkins (1903: 506).
Salarias leopardus Day (1869: 518), Ceylon material.
Blennius leopardus Day (1876: 325), Hawaii and Ceylon material.
Alticus brevis. Jordan and Evermann (1905: 17).
Exallias brevis. Jordan and Evermann (1905: 503); Jordan and Seale (1906: 431); Jordan and Jordan (1922: 83); Strasburg and Schultz (1953: 128).
Cirripectes brevis. Fowler (1922: 84; 1928: 432; 1938: 300; 1949: 149); Tinker (1944: 342).
Cirripectes leopardus. Schultz (1941: 18; 1943: 272); Fowler (1949: 149).
Cirripectus leopardus. Norman (1943: 810); Chapman, in de Beaufort and Chapman (1951: 247).
Cirripectus brevis. Norman (1943: 810).
Leoblennius schultzi Reid (1943: 382); Fowler (1949: 148).

The confusion regarding the names *brevis* and *leopardus* has been corrected by Strasburg and Schultz (1953), and to their synonymy

must also be added *Leoblennius schultzi* Reid (1943: 382). The holotype of *L. schultzi* was examined and found to be a late larval stage of *E. brevis*. A similar larva formed the basis for Schultz's earlier genus *Gloriella*.

E. brevis is a handsomely marked but rather uncommon blenny in Hawaii. As noted in the key, its color pattern consists of clusters of dark spots on a light background. In most fresh specimens the ground color is white or creamy, and the spots range from brown to almost black. In mature males the spongy pads covering the anal spines are deep indigo. Most specimens have been obtained from depths of 4–10 feet, but a series of three large males was taken at 20–35 feet off Waikiki on December 31, 1952. These males differed from others in that they were bright reddish orange marked with brown spots. It is possible that this vivid coloration is associated with habitat or perhaps breeding, since masses of blenny (?) eggs were found nearby.

Little is known of the habits of this fish. All but one of the mature specimens examined were taken by the use of rotenone; the exception was speared in shallow water. The species is widespread throughout the Indo-Pacific but is apparently nowhere common.

MATERIAL EXAMINED: Holotype of *Leoblennius schultzi*, 1 other Oahu, 5 "Hawaii," and 3 Johnston Is. at USNM; 1 Oahu at BPBM; 5 Oahu, 2 Kauai, 1 Hawaii, and 1 Johnston Is. at UH; 1 Lanai at POFI; 2 Hawaii at DFG.

Genus CIRRIPECTUS Swainson

Cirripectus Swainson (1839: 79–80, *Cirripectes* on pp. 182, 275). Type of genus, *Salarias variolosus* Valenciennes.

Cirripectus obscurus (Borodin)

Cirripectes alboapicalis. Fowler (1923: 389; 1927*b*: 91; 1928: 433; 1938: 300); Tinker (1944: 342).

Exallas obscurus Borodin (1927: 1, type locality Oahu).

Exalias obscurus Borodin (1928: 53).

Cirripectes obscurus Borodin (1928: 54).

Cirripectes variolosus. Schultz (1941: 20, in part); Fowler (1949: 148, in part).

Cirripectus variolosus. Chapman, in de Beaufort and Chapman (1951: 250, in part).

In a report on the fishes of Lord Howe Island, Ogilby (1899: 742) described *Salarias alboapicalis* as new, the species being characterized and named because of a conspicuous white patch located anteriorly and distally on the spinous dorsal fin. McCulloch and McNeill (1918: 23), although disagreeing with Ogilby on other characters of the species, present a figure of a Lord Howe specimen which clearly shows the fin-marking noted by Ogilby. While these records are extralimital to the present study they are worthy of note in that the descriptions and figures come very close to fitting a common Hawaiian blenny. This fish was initially identified as *C. alboapicalis* by Fowler (1923: 389) but later described as a new species, *Exallias obscurus*, by Borodin (1927: 1), both names ultimately being relegated to the synonymy of *C. variolosus*.

Dr. Gilbert P. Whitley of the Australian Museum has kindly examined all specimens referable to *Cirripectus* in that institution. His counts on the Lord Howe cotypes of *alboapicalis* (the holotype is lost) are in close agreement with those obtained from Hawaiian material, but the fading of his specimens precludes adequate color notes. In any case both the Lord Howe *alboapicalis* and the Hawaiian form are quite distinct from *variolosus*, and further, appear to be separable themselves. The holotype of *C. obscurus* (Borodin) and numerous other Hawaiian specimens referable to that species have been examined, and in none of them is the dorsal fin characterized by the white membrane shown by McCulloch and McNeill (1918: pl. 4). Furthermore, no specimens of *obscurus* show any

indication of white spotting on the anal fin as depicted for *alboapicalis* by these authors. It is felt that these differences in coloration warrant the separation of *obscurus* from *alboapicalis* until such time as fresh Lord Howe material is available.

The color pattern of *C. obscurus* is somewhat variable, a 113 mm. freshly-killed male being marked as follows: head and anterior trunk rose, shading to rosy brown, covered with small white dots; posterior trunk and tail dark brown, covered with scattered white dots, and with a series of eight broken olive bars on sides; first dorsal rosy; second dorsal dusky rose shading to purple; anal indigo; pectorals purple; caudal rose; nuchal cirri dark blue; nasal and supraorbital cirri red; iris golden. A 94 mm. female had the body golden brown with darker mottlings and covered with small white dots; the fins and other structures were as in the male except that the anal fin bore two lengthwise red stripes.

C. obscurus is probably the largest and among the most colorful of the Hawaiian blennies. Specimens of standard lengths up to 135 mm. are common over rocky bottoms at depths of from 4 to 20 feet. The species must be regarded as an Hawaiian endemic for the present. Its affinities appear to lie with *alboapicalis* and also with an as yet undescribed blenny (USNM Nos. 65412 and 65413) from Easter Island.

MATERIAL EXAMINED: Holotype of *C. obscurus* (Borodin) at AMNH; 30 Oahu, 7 Hawaii at UH; 39 Oahu in writer's collection.

Cirripectus lineopunctatus, new species
Fig. 1

HOLOTYPE: USNM No. 164198, a male, 59 mm. in standard length, taken in a shallow-water rotenone station at Kaena Point, Oahu, T.H., on March 19, 1950, by Gosline, Strasburg, Banner, and Sherman.

PARATYPES: USNM No. 164199, 8 specimens, 28–69 mm. in standard length, taken with holotype; USNM No. 164201, 5 specimens, 28–44 mm. in standard length, taken in a shallow-water rotenone station just north of Makapuu Point, Oahu, T.H., on Sept. 28, 1950, by Gosline and party; USNM No. 164200, 6 specimens, 36–62 mm. in standard length, taken in a rotenone station at depths of 5–30 feet, Hanauma Bay, Oahu, T.H., on Sept. 16, 1951, by Gosline and Holland.

It is probable that, if previously taken, this

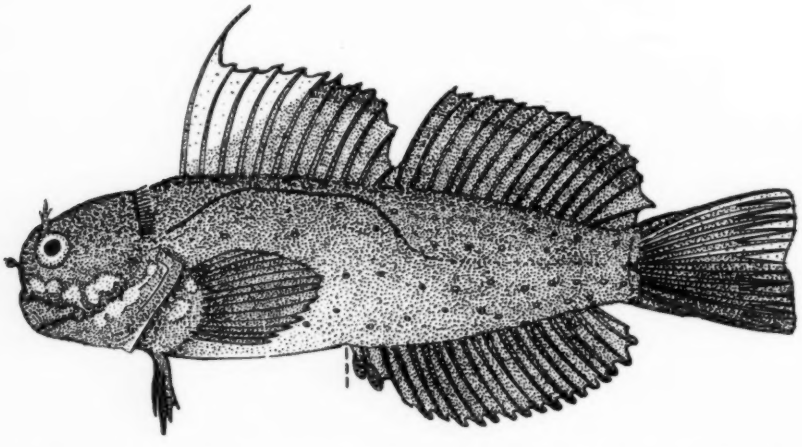

FIG. 1. Holotype of *Cirripectus lineopunctatus*, new species (USNM No. 164198) from Kaena Point, Oahu. Scale represents 20 mm.

species has been confused with either *C. obscurus* or *variolosus*. Fowler (1941: 276) reports a specimen of *variolosus* from Waianae, Oahu, which is marked somewhat as *lineopunctatus*. His description is inadequate for definite identification, and the specimen has not been seen.

DESCRIPTION: Counts made on *lineopunctatus* are recorded in Table 2, and detailed measurements, expressed in thousandths of the standard length, appear in Table 4.

Dorsal rays XII, 15 (very rarely 16); anal II, 15–17 (rarely 15 or 17), first anal spine embedded in females; pectoral 15; pelvics I, 4; branched caudal rays 5+4; fringe of cirri on nape 25–32; nasal cirri 3–6, usually 5; supraorbital cirri usually slender and unbranched, or if branched, branches arise from a central axis and never number more than 5.

Head 3.5 or 3.6; greatest depth 3.2–4.1; longest dorsal spine 3.3–5.4 (spine elongate in mature males); longest pectoral ray 4.6–5.1; all in the standard length. Eye 4.1–4.7; snout 2.9–3.3; interorbital space 8.3–9.3; postorbital length of head 1.5; least depth of body 2.4–2.7; greatest depth of body 0.9–1.1; all in length of the head; snout 1.2–1.4 in least distance between eye and nuchal fringe.

Supraorbital cirrus commonly a simple tapered flap; in some specimens a few branches arise from near its base, but cirrus base is never notably enlarged (as in *C. obscurus* and *variolosus* where it resembles a candelabrum); nuchal band of cirri interrupted on middorsal line, extending ventrally to level of pupil, cirri usually simple; snout profile nearly vertical; edge of upper lip with about 35–40 short fleshy papillae; lower lip plicate laterally, weakly papillate mesially, and with a short flap lateral to plicate portion; lateral line arched over pectoral fin, then running along midsides to base of caudal; tip of depressed pectoral just reaches anus; anal spines two, first embedded in mature females, both enclosed in convoluted pads of fleshy tissue in mature males; membrane between eleventh dorsal spine and first soft ray deeply notched, minute twelfth dorsal spine at base of notch; membranous attachment of last dorsal ray to caudal peduncle ending directly above flexure marking caudal fin base; fifth pectoral ray from lowermost edge of fin longest; caudal fin subtruncate, occasionally slightly concave; a curved canine present posteriorly on dentary; incisiform teeth in both jaws very numerous, of equal size, and freely movable.

Color in alcohol. Ground color light to dark brown; trunk and tail with 3–5 irregular lengthwise rows of light dots, many of which are rimmed with black; a few black dots posteriorly on tail; cheeks, snout, upper lip, and pectoral bases brown, irregularly marbled with white; throat and belly brown; dorsal fin blackish, sometimes a few white dots on posterior part; membrane between first few dorsal spines unpigmented and transparent distally, line of demarcation between pigmented and pale portions running from base of first spine to tip of about sixth spine; anal fin plain blackish or with a few white dots in males, abundantly spotted with white in females; tissue covering anal spines of males grayish; lower lobe of caudal blackish in males, spotted with white in females; upper lobe of caudal white or gray in both sexes; pectorals brownish with weak indications of white spotting in both sexes; pelvics brown; nuchal, supraorbital, and nasal cirri dusky.

Color in life. Head, body, and fins dark brown; cheeks, upper lip, and pectoral bases mottled with light olive; body covered with small black-rimmed white or yellow dots arranged in lengthwise rows and frequently aligned vertically; small black dots, also arranged in rows, sometimes present; dorsoanterior part of spinous dorsal red; nuchal cirri blackish; supraorbital cirri red or black; nasal cirri red.

RELATIONSHIPS: *C. lineopunctatus* is most closely related to *C. quagga*. The latter was described from Wake Island (Fowler and Ball, 1924: 273) but has also been taken throughout the Indo-Pacific region (Chapman, in de Beaufort and Chapman, 1951:

255). By comparing the description of *lineopunctatus* with that of *quagga* given by Strasburg and Schultz (1953) it is apparent that the two have the following characters in common: about the same number of nuchal cirri and dorsal, anal, and pectoral rays; a simple or occasionally multifid supraorbital cirrus; a high ratio for the least distance between the eye and nuchal fringe compared to the snout length; and a color pattern in part composed of light and dark dots on a brown background. Examination of fresh specimens of *quagga* obtained by Gosline and Randall at Wake in 1953 shows that the two forms are separable as follows. In *quagga* two dark lines extend transversely across the throat and are continued on the cheeks and suborbital regions; in *lineopunctatus* the throat is uniform brown. In *quagga* the sides are marked with 10–16 dark vertical bars, these being very distinct in light-colored specimens but obsolescent in dark or large individuals, with some indications persisting in all but the most melanistic specimens. In *lineopunctatus* there is never any indication of dark bars on the sides from standard lengths of 29 to 69 mm. In *quagga* the white dots on the sides are not rimmed in black (based on preserved material and Fowler's figure [1928: 437]), while in *lineopunctatus* they are. There are also minor tendencies for the mean dorsal and anal ray counts to be greater in *lineopunctatus*, while the mean number of its nuchal cirri is slightly less than in *quagga*.

So far as known, *C. lineopunctatus* is limited to Hawaii and Johnston Island. The species is moderately common at depths of 4–10 feet, and occurs in rocky areas subject to a fairly strong surf. It has been named *lineopunctatus* in reference to the lengthwise rows of dots on the body.

MATERIAL EXAMINED: Holotype, paratypes, and 7 Johnston Is. at USNM; 5 Oahu and 3 Johnston at UH.

Cirripectus variolosus (Valenciennes)

Salarias variolosus Valenciennes, in Cuvier and Valenciennes (1836: 317, type locality Guam); Fowler (1901: 518); Jenkins (1903: 507).

Alticus variolosus. Jordan and Evermann (1905: 17, 497); Jordan and Seale (1906: 424).

Cirripectes variolosus. Fowler (1922: 84; 1928: 433; 1938: 243, 300; 1949: 148); Tinker (1944: 342); Edmondson (1946: 352).

Rupiscartes variolosus. Jordan and Jordan (1922: 83); Fowler and Ball (1925: 29).

Cirripectes alboapicalis. Pietschmann (1938: 44).

Ophioblennius vanderbilti Fowler (1938: 242, 300; 1949: 148); Reid (1943: 380).

Ophioblennius capillus Reid (1943: 381); Fowler (1949: 148).

Cirripectus variolosus. Fowler (1941: 276); Chapman, in de Beaufort and Chapman (1951: 249).

Its wide distribution and number of close relatives has caused *C. variolosus* to present a confusing taxonomic picture, part of which was corrected by Strasburg and Schultz (1953). Like *Exallias brevis* this blenny has distinctive larval stages which have been the basis for the erection of *Ophioblennius vanderbilti* and *O. capillus*. Chapman (in de Beaufort and Chapman, 1951: 251), correctly synonymized *O. vanderbilti* with *variolosus* but apparently overlooked Reid's *O. capillus*. The holotype of this species was examined and found to be another large larva of *C. variolosus*. The dentition differences between it and *O. vanderbilti* noted by Reid (*op. cit.*: 382) are probably ascribable to damage or to its greater ontogenetic age. Pietschmann's record of *C. alboapicalis* (1938: 44) from Pearl and Hermes Reef is obviously based on specimens of *C. variolosus*.

Color in life: head brown, with or without bright red markings; body olive-brown to deep brownish black, often with a blue or purple sheen; upper portions of dorsal and caudal fins red, rest of these fins blackish; anal fin deep blue-black; nasal and supraorbital cirri either red or brown; nuchal cirri brown. In preservative, red markings dis-

appear from head, and red fin membranes become colorless or white, leaving specimens uniform leather-brown or blackish.

C. variolosus is one of the most numerous Hawaiian blennies, being taken in nearly every rotenone station at depths of from 2 to 30 feet. It abounds particularly on the shallow "dead" reefs such as characterize Waikiki, and a swimmer may see numerous specimens flitting in and out of crevices. The species is widespread throughout the Indo-Pacific area.

MATERIAL EXAMINED: Holotype of *O. capillus* at USNM; 28 Oahu, 3 Kauai, 51 Johnston, 2 French Frigate Shoals, and 4 Midway at UH; 1 Maui and 1 Hawaii at POFI; 23 Oahu in writer's collection.

TABLE 2
COUNTS MADE ON HAWAIIAN SPECIES OF *Cirripectus*

		C. obscurus	*C. lineopunctatus*	*C. variolosus*
Dorsal fin	XI	1		
	XII	76	35	114
	13			1
	14			108
	15	4	34	5
	16	73	1	
Anal fin	II	77	35	114
	14			4
	15	1	1	107
	16	11	30	3
	17	65	4	
Pectoral fin (both sides counted)	13			1
	14	1	1	
	15	85	53	51
	16	2		1
Total nuchal cirri	25–26		5	
	27–28		15	
	29–30		12	
	31–32		3	6
	33–34			17
	35–36			25
	37–38	9		42
	39–40	20		15
	41–42	26		6
	43–44	16		1
	45–46	2		
Supraorbital cirri (both sides counted)	1		62	
	2		3	1
	3		2	4
	4	4	2	12
	5	43	1	41
	6	67		54
	7	23		61
	8	5		35
	9			9
	10			3
	11			1

Genus ENTOMACRODUS Gill

Entomacrodus Gill (1859: 168).Type of genus, *Entomacrodus nigricans* Gill.

Entomacrodus marmoratus (Bennett)
Fig. 2

Blennius marmoratus Bennett (1828: 35, type locality Sandwich Islands).

Salarias marmoratus. Günther (1861: 248, 562; 1877: 204, but not pl. 116, fig. B); Jenkins (1903: 507); Snyder (1904: 536); Fowler (1927*a:* 29, in part; 1928: 435, in part; 1934: 445, in part; 1938: 243, 300, in part; 1940: 794; 1941: 276; 1949: 149, in part); Galtsoff (1933: 20); Tinker (1944: 342, but not his figure).

Alticus marmoratus. Jordan and Evermann (1905: 5, 7, 10, 23, 498, but not fig. 220); Jordan and Seale (1906: 424); Fowler (1922: 84).

Rupiscartes marmoratus. Jordan and Jordan (1922: 83); Fowler and Ball (1925: 29, in part).

Salarias meleagris. Fowler (1923: 389; 1928: 440; 1938: 301; 1949: 150); Tinker (1944: 344); Edmondson (1946: 352).

Rupiscartes striatus. Fowler and Ball (1925: 28).

Istiblennius marmoratus. Norman (1943: 812).

Entomacrodus marmoratus. Chapman, in de Beaufort and Chapman (1951: 272, 283, 285).

Although Norman (1943: 807) was the first to properly define the genus *Entomacrodus* he failed to place *marmoratus* and other

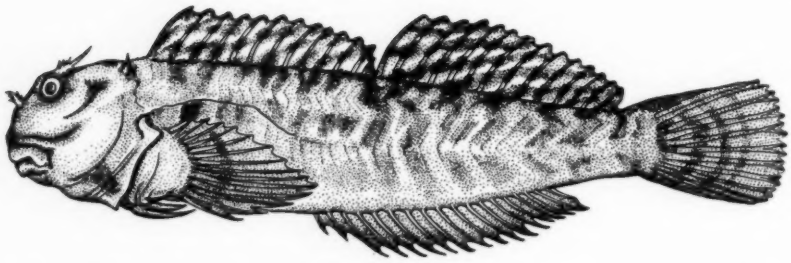

FIG. 2. *Entomacrodus marmoratus* (Bennett), based on a specimen 95 mm. in standard length from Hanauma Bay, Oahu.

congeners in it, probably because of difficulty in determining the presence of vomerine teeth, the salient generic character. Chapman (de Beaufort and Chapman, 1951: 272), discusses six Indo-Australian species of *Entomacrodus*, and also mentions seven others, including *marmoratus*, from other parts of the Pacific and the tropical Atlantic. The recorded distribution of *marmoratus* covers much of the Indo-Pacific, but both Chapman's work and the manuscripts for the Bikini studies demonstrate that the non-Hawaiian records are based on other species. It has not been possible to investigate many records extra-limital to this study, but both Fowler and Ball's record from Wake Island (1925: 29) and Smith's from South Africa (1950: 508, pl. 75) were seen and found to be other species. Fowler's records of *S. meleagris* from Hawaii (see synonymy) were also checked and found to be based on specimens of *marmoratus*. It should be noted that neither Günther's figure (1877: pl. 116, fig. B), Jordan and Evermann's (1905: fig. 220), nor Tinker's (1944: 343) actually represent *marmoratus*. Figure 2 is here supplied as an illustration of this blenny.

As noted in the key, the quickest method of identifying *E. marmoratus* is by the presence of two (sometimes only one in juveniles) cirri on each side of the nape. The lateral member of each pair is a short simple filament while the mesial one is commonly multifid. Unfortunately, only the mesial cirrus is clearly visible in Figure 2. The presence of vomerine teeth, while of considerable taxonomic importance, is hardly useful in routine species determination. Dissection and staining are almost necessities to see the series of about a dozen minute conical teeth on the vomer. Other distinguishing characters are presented in the key.

The mottled color pattern of *marmoratus* is well shown in Figure 2 but the actual colors involved are rather variable. The dark blotches are a rich brownish black in life and the belly is pure white. The ground color of the rest of the fish consists of various shades of olive-brown, brownish pink, or olive-green, with olive-brown the most common.

E. marmoratus abounds in areas of heavy surf such as occur along the rocky shores of the Hawaiian Islands. It is commonly seen leaping into the surf or skittering across the surface of rough water. Specimens are easily obtained by the use of rotenone, by pole-fishing using tiny hooks, or by scoop net. The species is endemic to Hawaii and appears to be most closely related to *E. epalzeocheilos* (Bleeker) of the East Indies, Indian Ocean, and Samoa. Distinguishing features of *epalzeocheilos* are given by Chapman (de Beaufort and Chapman, 1951: 274, 281).

MATERIAL EXAMINED: 16 Hawaiian Is., 5 Oahu, 9 Molokai at USNM; 35 Midway at UH; 1 Laysan, 2 Oahu at BPBM; 7 Lanai, 5 Oahu, 3 Hawaii, 31 Maui at POFI; 1 Hawaii at DFG; 108 Oahu in writer's collection.

Genus ISTIBLENNIUS Whitley

Istiblennius Whitley (1943: 185). Type of genus, *Salarias mulleri* Klunzinger.

This genus, as here understood, includes those blennies which possess the following characters: teeth (excluding canines) freely movable in both jaws; trunk lateral line well developed; ventral rays I, 2 or 3; branched caudal rays 5 above plus 4 below except in very young; a tentacle over each eye; spinous and soft dorsal separated by a distinct notch in their connecting membrane. Its species lack the following characters possessed by related genera: transverse fringe of nuchal cirri, sucking appendage on lower lip, elongate anterior anal rays, vomerine teeth, and membranous connection of last anal ray to caudal peduncle. Even with the above restrictions the genus is probably heterogeneous, and has been described by Norman (1943: 811) as a ". . . large and varied assemblage of species."

Members of *Istiblennius* have been observed by the writer in the Hawaiian, Marshall, and Gilbert Islands, and were found to fall into two natural groupings on morphological and ecological grounds. In one group a stout canine tooth is present posteriorly on the dentary and there is a prominent bulging of the forehead so that the snout slopes backward from the eye to the mouth. Species included here are *I. gibbifrons* in Hawaii and *I. paulus* and *coronatus* in the Central Pacific. All three characteristically occur on submerged reefs at depths of from 1 to 4 feet, and they rarely frequent supratidal habitats.

The second group of species lacks the canine teeth and bulging forehead of the first, and includes *I. zebra* in Hawaii and *I. edentulus* and *lineatus* of the Central Pacific. All of these are found in either supra- or intertidal pools and only rarely on submerged reefs. A study of *zebra* and the descriptions of eight other members of the second group listed by Chapman (de Beaufort and Chapman, 1951), indicates other phyletic tendencies which are probably sufficiently strong to warrant the separation of the two groups as distinct subgenera or genera. As noted in the introduction, however, it is felt that such separation should not be attempted outside of monographic treatment, and thus is not included here.

Istiblennius zebra (Vaillant and Sauvage)

Salarias zebra Vaillant and Sauvage (1875: 281, type locality Sandwich Islands); Snyder (1904: 536); Jordan and Evermann (1905: 501); Jordan and Seale (1906: 426); Jordan and Jordan (1922: 83); Fowler and Ball (1925: 29); Fowler (1927*a*: 30; 1928: 439; 1934: 446; 1938: 244, 301; 1940: 796; 1941: 276; 1949: 150, in part); Pietschmann (1938: 45); Tinker (1944: 344); Edmondson (1946: 352).

Salarias edentulus. Fowler (1901: 517; 1922: 84; 1928: 438, in part; 1938: 301; 1949: 150); Steindachner (1901: 499, 520); Jordan and Evermann (1905: 15, 17, 503); Jordan and Jordan (1922: 83); Tinker (1944: 343); Chapman, in de Beaufort and Chapman (1951: 331).

Salarias cypho Jenkins (1903: 506).

Scartichthys zebra. Jordan and Evermann (1905: 11, 19).

Alticus zebra. Jordan and Evermann (1905: 24, 27).

Istiblennius zebra. Norman (1943: 812); Strasburg (1955: 299).

As pointed out by Strasburg (1955: 299) there has been some confusion in the literature with respect to *I. zebra* and *I. edentulus* (Bloch, in Bloch and Schneider, 1801: 172), and the two are undoubtedly closely related. The fin ray counts of Hawaiian "*edentulus*" given by Steindachner (1901: 499) are sufficiently complete to show that he dealt with *zebra*, and some Hawaiian *edentulus* listed by Fowler (1928: 438) have been examined and also found to be *zebra*. Other specimens of *edentulus* from Hawaii (Fowler, 1901: 517; 1922: 84; 1938: 301; and Tinker, 1944: 343–

344) have not been seen, and their taxonomic status is subject to some doubt. Records of *zebra* from Tahiti (Fowler, 1949: 150) and the Tuamotus (Harry, 1953: 134) are possibly based on a species still undescribed but perhaps identical to one noted by Chapman (de Beaufort and Chapman, 1951: 331), from the Marquesas.

Among Hawaiian blennies, *I. zebra* is unique in its possession of a high fleshy crest along the midline of the head. This crest is present in both sexes at lengths greater than 50 mm., but appears earlier and attains a greater size in males. Specimens too small to have the crest could be confused only with *I. gibbifrons*, *E. marmoratus*, or perhaps *Omobranchus elongatus*. Separation from these can be accomplished by the fact that *zebra* has no canine teeth, lacks nuchal cirri, and has a notched dorsal fin.

Life coloration of adult *zebra* varies from bluish black through gray to yellowish brown, the sides commonly being marked with a series of gray or tan vertical bars. In large specimens the fins may be irregularly blotched with red, and in males the cheeks may be dull orange.

This blenny abounds in pools on rocky coasts, being particularly common on Oahu along the Koko Head coast, on Rabbit Island, and on the rocky shores between Waimea and Kaena Point. It is generally restricted to supra- or inter-tidal pools, and was taken only twice by the writer from submerged reefs. The species is not known from Midway or Johnston islands, probably because of a lack of suitable habitats, but may otherwise be regarded as endemic to the Hawaiian area.

MATERIAL EXAMINED: 34 Oahu, including holotype of *Salarias cypho*, 31 Necker, 31 Laysan, 24 Hawaii, 30 Maui, and 3 "Hawaiian Islands" at USNM; 1 Maui, 4 Hawaiian Islands at MCZ; 87 Oahu in writer's collection.

Istiblennius gibbifrons
(Quoy and Gaimard)

Salarias gibbifrons Quoy and Gaimard (1824: 253, type locality Hawaiian Islands); Valenciennes, in Cuvier and Valenciennes (1836: 312); Günther (1861: 251; 1877: 205); Fowler (1901: 517; 1928: 437; 1934: 446; 1938: 243, 301; 1949: 150); Snyder (1904: 536); Pietschmann (1938: 45); Tinker (1944: 343); Chapman, in de Beaufort and Chapman (1951: 342, in part).

Salarias saltans Jenkins (1903: 508).

Salarias rutilus Jenkins (1903: 509).

Alticus gibbifrons. Jordan and Evermann (1905: 4, 10, 17, 19, 27, 499); Jordan and Seale (1906: 423); Fowler (1922: 84).

Entomacrodus gibbifrons. Jordan and Evermann (1905: 23).

Rupiscartes gibbifrons. Jordan and Jordan (1922: 83); Fowler (1925: 30); Fowler and Ball (1925: 29).

Salarias periophthalmus. Fowler (1928: 439, in part).

Istiblennius gibbifrons. Norman (1943: 812).

Blenniella rhessodon Reid (1943: 383); Fowler (1949: 148).

Dissimilarities between various growth and sexual forms of *gibbifrons* have resulted in males and females being described as separate species (Jenkins, 1903) and a larval stage as a new genus and species (Reid, 1943). Sexual dimorphism was clarified by Snyder (1904), and the writer's examination of the holotype of *Blenniella rhessodon* revealed it to be a late larval stage of *I. gibbifrons*. Fowler (1928: 439) lists MCZ as having Hawaiian specimens of *Salarias periophthalmus*, but upon examination these proved to be *I. gibbifrons*.

I. gibbifrons has been widely recorded from the Pacific Ocean, but Chapman (de Beaufort and Chapman, 1951: 344), limits its certain distribution to Hawaii and adjacent regions. Unpublished work on the blennies of the northern Marshall Islands by Schultz and Chapman indicates that a closely related Marshallese form is specifically distinct, but the writer's examination of specimens from Wake Island (only 500 miles north of Bikini) showed them to be indistinguishable from

the Hawaiian form. The Hawaiian form is also abundant at Johnston Island, but no specimens were found in a collection from Palmyra. In view of these circumstances, *gibbifrons* may probably be regarded as limited to the area immediately around the Hawaiian Islands.

Jenkins' figures (1903: 508–509) are duplicated by Jordan and Evermann (1905: 499–500) and give an excellent representation of the color pattern of the two sexes of *gibbifrons* ("*saltans*" is a male, and "*rutilus*" a female). Unfortunately, neither figure depicts the bulbous forehead characteristic of this group of blennies (see generic diagnosis). Life coloration consists of a pale olive or tan ground color overlaid with a network of fine golden-brown lines. Females bear a series of eight dusky bars on the trunk and tail but these are much less obvious in males. In males the sides are marked with rows of small bluish white ocelli, and the spinous dorsal is dusky distally. In females this duskiness is usually reduced to a single black spot in the membrane between the first two spines.

I. gibbifrons occurs on permanently submerged reefs at depths less than about 4 feet. It is common at Waikiki and also on limestone benches along the Waianae coast. The species is very alert and agile and can be taken easily only with rotenone. Large larvae are phototaxic and numerous specimens have been taken at night using an electric surface light.

MATERIAL EXAMINED: Holotype of *Blenniella rhessodon* at USNM; 7 Sandwich Islands at MCZ; 22 Midway, 22 Johnston, and 31 Oahu at UH; 1 French Frigate Shoals, 1 Nehoa, 1 Oahu, 3 Maui, 2 Hawaii at POFI; 35 Hawaii in writer's collection.

Genus ECSENIUS McCulloch

Ecsenius McCulloch (1923: 121). Type of genus, *E. mandibularis* McCulloch.

Ecsenius hawaiiensis Chapman and Schultz

Ecsenius hawaiiensis Chapman and Schultz (1952: 526, type locality Pearl Harbor, Oahu).

The peculiar circumstances leading to the capture of the only known specimens of this blenny have been mentioned in the discussion of *Tripterygion atriceps*. Suffice it to say that fish living in the fouling on the bottom of a barge brought to Hawaii from Guam may not necessarily be Hawaiian species. Chapman and Schultz's statements (1952: 528) concerning the Hawaiian nature of the barge's fauna have been shown to be in error for *Tripterygion*, and may also be so for *Ecsenius*. Regardless of its geographic origin, however, *E. hawaiiensis* may now have established itself on Oahu, and is therefore included in this report.

E. hawaiiensis may be quickly distinguished from other Hawaiian blennies by its lack of supraorbital cirri and by the fact that the teeth in the upper jaw are freely movable, whereas those in the lower jaw are fixed. Mr. Kenneth Wong, formerly of the Honolulu Aquarium, noted that living specimens of the type series of *E. hawaiiensis* were purple anteriorly and yellow posteriorly. Preserved specimens are plain olive or brownish, with no indication of this regional color differentiation. The vertical white bars noted on the sides by Chapman and Schultz (1952: 527) are not present on all specimens, and these authors' figure does not clearly depict the basal black spot between the first three dorsal spines. Other distinguishing characters are given in the key.

Little is known concerning the biology of the genus *Ecsenius* aside from Chapman and Schultz's general statements of its occurrence at moderate depths as opposed to shallow reefs. If it is normally a deep water form it is possible that specimens of *E. hawaiiensis* will not be taken for some time, even if well established in the Hawaiian area. So far as known, the species has been taken only from the Hawaiian Islands.

MATERIAL EXAMINED: Holotype and 12 paratypes at USNM; 1 Oahu taken with the type series and retained at UH.

Genus ENCHELYURUS Peters

Enchelyurus Peters (1868: 268). Type of genus, *Enchelyurus flavipes* Peters.

In setting up *Enchelyurus*, Peters presents the following diagnostic characters: dentition and lack of scales as in *Petroscirtes*, gill opening as wide as pectoral base, and dorsal and anal fins united with the caudal. Norman (1943: 798) uses the united vertical fins as a major character, but further limits the genus to species with gill openings extending about halfway down the pectoral bases, even though his list of pertinent species (*op. cit.*: 804) includes *flavipes* which has much larger gill openings. The writer's examination of *flavipes*, *kraussi*, *ater*, *hepburni*, and *brunneolus* showed that *Enchelyurus*, as used by Norman, is not only poorly defined but probably also polyphyletic. A review of this and related genera is not possible at present, and the genus *Enchelyurus* is temporarily used for those blennies with no scales, fixed teeth, and united vertical fins.

Enchelyurus brunneolus (Jenkins)

Aspidontus brunneolus Jenkins (1903: 510, type locality Honolulu); Snyder (1904: 536).

Enchelyurus ater. Jordan and Evermann (1905: 19, 27, 500); Jordan and Seale (1906: 434); Jordan and Jordan (1922: 83); Fowler (1925: 30; 1928: 443; 1934: 447; 1938: 301; 1949: 151); Fowler and Ball (1925: 29); Pietschmann (1930: 22; 1938: 50); Tinker (1944: 345).

Enchelyurus edmondsoni Fowler (1923: 389; 1928: 443–444; 1938: 301; 1949: 151); Norman (1943: 804); Tinker (1944: 345).

Jordan and Evermann synonymized *brunneolus* with the closely related *E. ater* (Günther, 1877: 199) in 1905. The latter species occurs in the southeastern Pacific, and on the average differs from *brunneolus* of Hawaii as follows: *brunneolus* has 14 pectoral rays, *ater* has 15; in *brunneolus* the gill opening extends ventrally to the level of the fifth or sixth pectoral ray, in *ater* it extends to the eighth to tenth; *brunneolus* has 10 dorsal spines while *ater* has 9; and in *brunneolus* there are 19 or 20 soft anal rays whereas *ater* has 17–19. Dr. N. B. Marshall, of the British Museum, has kindly confirmed these findings for the holotype of *Petroscirtes ater* Günther.

Some sexual dimorphism occurs in *brunneolus*, the general picture being that females are uniform blackish brown or black, whereas in mature males the trunk and tail are black and the throat, gill membranes, and cheeks are gray with black spots and bars. In males the dorsal fin is traversed by a series of narrow black lines running posteriorly and dorsally; in females this fin is nearly uniform black with an intensely black spot between the first two spines. Finally, in mature males the anal fin is marked with two or three dark lengthwise stripes and the tips of the rays are somewhat enlarged and arrow-shaped. In females the anal fin is uniform black and the rays have a normal taper.

The holotype of Fowler's *E. edmondsoni* was examined and found to be a mature male *brunneolus*. The specimen is now a light brown and probably too discolored to permit an adequate color description to be made. Fowler's figure of the holotype of *edmondsoni* (1928: 444) is very misleading in that he shows the species to have dark markings on a white or very light background, whereas actually the ground color is quite dark and the markings even darker. The lengthwise bands on the trunk and tail shown by Fowler are neither mentioned in the type description (1923: 390) nor visible on the holotype.

The fact that this blenny is nearly jet black in color and rarely exceeds an inch in length makes it quite easy to recognize. It could be confused only with juvenile *Cirripectus*, but can be readily told from these by its lack of

nuchal and supraorbital cirri. Its united dorsal, caudal, and anal fins (except in the very young) also make it distinctive.

E. brunneolus is fairly common within the interstices of a dead coral reef, such as at Waikiki, and specimens may also be found clinging to the undersides of reef rocks. It is frequently overlooked in rotenone collecting because of its small size, but living specimens can be captured by splitting masses of coralline rock. The species is endemic to the Hawaiian area.

MATERIAL EXAMINED: *E. brunneolus*, holotype of *Aspidontus brunneolus* at USNM; holotype of *Enchelyurus edmondsoni* at BPBM; 21 Oahu, 1 Kauai, 2 French Frigate Shoals, 1 Laysan at UH; 10 Maui at POFI; 6 Oahu in writer's collection.

Enchelyurus ater, 21 Samoa at USNM; holotype of *Petroscirtes ater* (from Tahiti) at British Museum (examined by Dr. N. B. Marshall).

Genus OMOBRANCHUS (Ehrenberg) Valenciennes

Omobranchus (Ehrenberg) Valenciennes, in Cuvier and Valenciennes (1836: 287). Type of genus, *Blennechis fasciolatus* Valenciennes (ex *Omobranchus fasciolatus* Ehrenberg MS).

Omobranchus elongatus (Peters) Fig. 3

Petroscirtes elongatus Peters (1855: 249, type locality Mossambique).

Omobranchus elongatus. Norman (1943: 804, undoubtedly based on non-Hawaiian material).

Although Hawaiian specimens of *Omobranchus* appear to fit Peters' description of *elongatus* there is some doubt as to whether they are actually that species. Color pattern differences, perhaps ascribable to sexual dimorphism, have resulted in considerable confusion between *elongatus* and *kallosoma* of Bleeker (1858: 227). The two species have been synonymized by Günther (1877: 196) and Fowler (1928: 429) but regarded as distinct by Fowler (1949: 146) and de Beaufort (de Beaufort and Chapman, 1951: 374). A lack of comparative material has prevented a study of differences between these species, and the name *elongatus* is tentatively used because it fits fairly well and is the oldest available name.

The four known Hawaiian specimens of *O. elongatus* may or may not deserve a place in the fauna of the Hawaiian Islands. All were obtained from a concrete tank located on Coconut Island, Kaneohe Bay, Oahu, which has been figured by Tester (1952: 3). From Tester's photograph and description the following facts about this tank are of note. It is located on land but near water, its dimensions are about 11 by 35 feet with a depth of 4 feet, and it is supplied with running water from Kaneohe Bay by a submerged inlet and an overflow-type outlet. The biota of the tank normally consists of tuna, tunny, surgeon fish, and other moderately large experimental animals, a few small fish and crabs (which presumably enter with incoming water), and a variable growth of algae. During the spring of 1951 a number of pieces of coralline rock bearing *Tridacna* clams and undoubtedly other organisms were obtained from near the Samoan Islands and placed in the tank by the staff of the Pacific Oceanic Fishery Investigations, United States Fish and Wildlife Service, Honolulu. Sometime after the removal of these exotic elements the tank was pumped dry, painted, and restocked with Hawaiian experimental fish. On July 29, 1953, Messrs. Eugene Nakamura and John Randall, of the University of Hawaii, captured a living *Omobranchus* from the tank, and on September 26 of that year Randall took three more by draining the tank.

It was originally presumed that the four *Omobranchus* represented an indigenous Hawaiian form not previously taken because of some habitat peculiarity. Subsequent examination of collections from Palmyra Island

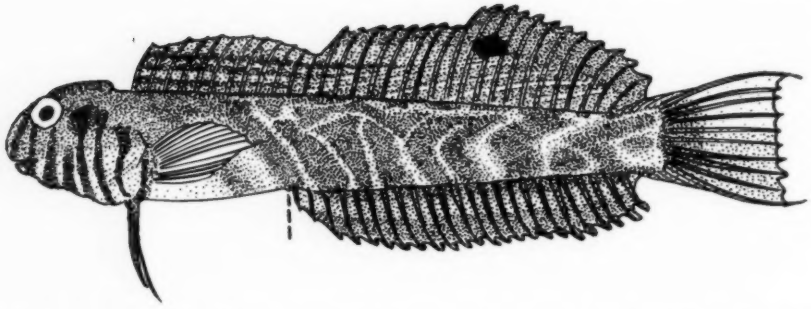

FIG. 3. *Omobranchus elongatus* (Peters), based on a mature male specimen from Coconut Island, Oahu. Scale represents 20 mm.

(a member of the Line group) showed a morphologically identical species to be present there, and it then appeared that perhaps the species was introduced into Hawaii when the *Tridacna* clams were brought to Coconut Island. If this is so, then it is difficult to explain how the fish withstood tank draining and painting. It is possible that they retreated a considerable distance into the inlet pipe, or that some had previously escaped, established a population in Kaneohe Bay, and then members of this population subsequently reentered the tank. That breeding populations have existed in Hawaii is evident from the size range of the four known specimens. The smallest of these is a gravid female measuring only 36 mm. in standard length; certainly this fish was hatched in Hawaii.

Regardless of the history and unorthodox locality record of *O. elongatus*, a strong possibility exists that it is now locally established in Hawaiian waters. The area where it is most likely to occur, Coconut Island and environs, has not been recently sampled because of the inadvisability of using rotenone near experimental ponds.

Counts and other distinguishing characters are given in Table 3 and the key, and the following color notes supplement Figure 3 as an aid in distinguishing this blenny.

Color in life. Body more or less translucent, vertebral column clearly visible in tail; ground color olive-brown becoming dull red below midsides, belly grayish white; dorsal half of body covered with a reticulum of narrow white lines; on sides reticulum breaks up into a series of narrow parallel lines which slant posteriorly and ventrally. Ground color of head olive-green; opercle dull red-brown anteriorly and with an oval red-brown area posterodorsally; preopercle olive-green dorsally, breaking up into two or three green streaks separated by yellowish interspaces ventrally; head with dark vertical bars bordered by irridescent blue-green lines as follows: red-brown bar from front edge of eye to snout, olive-green bar across cheek and throat below center of eye, red-brown bar across cheek and throat at rear edge of eye, two red-brown bars across preopercle and throat, the second not meeting its opposite member, a short red-brown bar across branchiostegals from tip of preopercle to lower pectoral base. Membrane of spinous dorsal pinkish, broken into numerous lengthwise stripes with clear interspaces, spines yellowish with white tips; membrane of soft dorsal yellowish-hyaline with a few diagonal pinkish lines basally, rays yellowish, their tips irridescent blue-white, and a brilliant blue-green spot between rays 10 to 12; caudal fin membrane hyaline, caudal rays yellow; anal fin yellowish-hyaline basally, gray distally, each ray with a conspicuous blue-white tip; pectorals yellow-hyaline; ventrals orange-yellow; iris bronze, pupil black (based on a male

specimen 52 mm. in standard length).

The specimen from which the above notes were made was placed alive into 5 per cent formalin upon which it developed a color pattern suprisingly different from that of life. All white and blue-green lines disappeared from the head and body, the interspaces between them turning dark brown and forming the oblique and vertical bars noted in the key. An oval black spot also appeared on the head behind the eye. The reported variability in the presence or appearance of the body bars or the head spot is probably partially dependent on how soon after death specimens are preserved.

Three of the Hawaiian specimens are males and have a standard length range of from 52 to 56 mm. All have the spot on the soft dorsal noted above and by Peters (1855: 249), and in the most mature specimen there is also a low fleshy ridge down the midline of the head, and a decided tendency for the tips of the last eight anal rays to be compressed and broad when viewed from the side. The single 36 mm. female lacks the soft dorsal spot, the head ridge, and compressed tips of the anal rays. Five specimens of what appears to be the same species from Palmyra Island have a length range of only 33–46 mm., yet all are sexually mature. Here, too, females lack the soft dorsal spot of the males.

The ecology of *O. elongatus* is not well known except as noted above for the collection locale. The Palmyra specimens came from a shallow inshore reef. Distribution of the species includes East Africa, the East Indies, and the Central Pacific.

MATERIAL EXAMINED: 4 Oahu in writer's collection; 5 Palmyra at UH.

Genus RUNULA Jordan and Bollman

Runula Jordan and Bollman (1890: 171). Type of genus, *Runula azalea* Jordan and Bollman.

Schultz's separation of *Runula* from *Aspidontus* (1950: 266) has been followed in this report.

Runula ewaensis (Brock)

Petroscirtes ewaensis Brock (1948: 125, type locality, off Ewa Beach, Oahu).

R. ewaensis is apparently a moderately deep-water inhabitant, and has been taken only rarely to date. Of the five known specimens, two came from depths of about 120 feet and one, the holotype, from 30 feet. It is of interest that the holotype and one of the specimens from 120 feet were taken from pipes hauled to the surface. It is suggested that examination of the pipe frameworks of Hawaiian fish traps might yield additional specimens and perhaps throw some light on the biology of this blenny.

An attempt has been made to determine the systematic position of *ewaensis*, and the species appears to be most closely related to *R. rhinorhynchos* (Bleeker, 1852: 273) of the East Indies, Palau, etc. Meristic differences between the two may be summarized briefly as follows: *ewaensis* has 34 or 35 soft dorsal rays while *rhinorhynchos* has 32 or 33; *ewaensis* has 32 or 33 soft anal rays, and *rhinorhynchos* has 29 or 30. From the standpoint of color pattern, *rhinorhynchos* has two plain, lengthwise blue stripes against a brownish background (cf. Smith, 1950: pl. 21, fig. 962), while in *ewaensis* these stripes are edged in black and the ground color is pale (brick red in life). Three Philippine specimens of *rhinorhynchos* at USNM differ from Smith's figure in having a black blotch on each side of the caudal peduncle which extends about one-third to one-half the length of the caudal fin. This spot is usually lacking in *ewaensis*, but when present it ends at the flexure denoting the caudal fin base. The brick red ground color and two lengthwise blue stripes are sufficiently distinctive to make identification of specimens an easy matter.

R. ewaensis has been reported only from Oahu and is regarded as endemic to the Hawaiian Islands for the present. Its habitats cannot be considered well sampled, however,

and it is possible that the species will be taken elsewhere.

MATERIAL EXAMINED: *R. ewaensis*, holotype and 1 other Oahu at USNM; 1 Oahu in collections of Honolulu Aquarium; 2 Oahu in writer's collection.
R. rhinorhynchos, 3 Philippines at USNM.

Runula goslinei, new species
Fig. 4

HOLOTYPE: USNM No. 164202, a female, 43 mm. in standard length, taken in a shallow-water rotenone station at Pupukea, Waimea coast, Oahu, T. H., on December 23, 1949, by Gosline, Strasburg, and party.

PARATYPES: USNM No. 164203, 1 specimen 38 mm. in standard length, taken with the holotype; USNM No. 164204, 1 specimen 37 mm. in standard length, taken in a shallow-water rotenone station at Makapuu Beach, Oahu, T. H., on October 2, 1952, by Gosline and party; USNM No. 108503, 1 specimen 38 mm. in standard length, caught on reef off Mokuleia, Waialua, Oahu, in 1937 by Otto Degener.

DESCRIPTION: Counts made on *R. goslinei* are recorded in Table 3, and detailed measurements, expressed in thousandths of the standard length, made on the holotype and two paratypes appear in Table 4.

Dorsal rays VIII, 34–37 (usually 35); anal II, 29 or 30, first anal spine minute and partially embedded in females; pectoral 12; pelvics I, 3, spine and mesial ray visible only

TABLE 3
COUNTS MADE ON SPECIES OF *Runula* AND *Omobranchus*

		R. goslinei	*R. tapeinosoma*	*R. ringens*	*O. elongatus* (OAHU)	*O. elongatus* (PALMYRA)
Dorsal fin	VII	1				
	VIII	10	11	12		
	IX		1	1		
	X		1			
	XI					
	XII				4	5
	19				3	4
	20				1	1
	32			1		
	33			6		
	34	1	1	6		
	35	6	4			
	36	1	8			
	37	1				
Anal fin	II	9	13	13	4	5
	20				1	
	21				1	4
	22				2	1
	27			3		
	28			4		
	29	6	3	5		
	30	2	9	1		
	31		1			
Pectoral fin (both sides counted)	10		1			
	11					
	12	16	15	23		
	13			3	8	10
Number of upper pectoral rays encompassed by gill openings (both sides counted)	4					6
	5	9	6	10	4	4
	6	5		16	4	

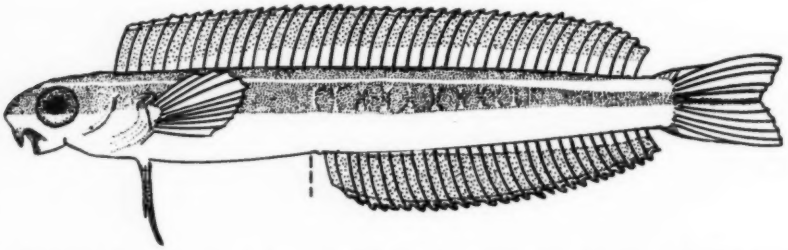

FIG. 4. Holotype of *Runula goslinei*, new species (USNM No. 164202) from Pupukea, Waimea Coast, Oahu. Scale represents 10 mm.

with staining and dissection; principal caudal rays 11, none branched; no nuchal, nasal, or supraorbital cirri; teeth incisiform, firmly attached, immovable, an enormous fang-like canine on dentary; incisiform teeth totaling 32–56 in lower jaw and 21–28 in upper, the number increasing with growth; gill opening a small slit running from above pectoral base to level of fifth or sixth ray from top of pectoral fin.

Head 4.0–4.5; greatest depth 6.9–7.9; longest dorsal spine 9.2–11.0; longest pectoral ray 7.3–8.2; all in the standard length; eye 3.2–3.8; snout 3.8–4.8; interorbital space 3.2–3.5; postorbital length of head 2.1; least depth of body 2.8–3.2; greatest depth of body 1.5–2.0; all in length of the head.

Dorsal fin entire, spinous part slightly lower than soft-rayed portion; last dorsal and anal rays membranously attached to caudal peduncle, attachment occurring anterior to small caudal rays; snout pointed; mouth subterminal, inferior; lips smooth; four tiny tentacles just posterior to lower lip in some specimens; lateral line absent (?); fifth or sixth pectoral ray from upper edge of fin longest, reaching posteriorly to level of second soft dorsal ray; caudal fin slightly forked.

Color in alcohol. Lower half of head and body silvery white, upper half brown, the two colors sharply separated at level of lower edge of pupil; a narrow white line down dorsal midline of head from near tip of snout to base of first dorsal spine; a second narrow white line from side of snout to dorsolateral portion of caudal peduncle, touching upper edge of eye and broadening beneath soft dorsal; second line divides brown portion of body into a narrow upper band and a broader lower one; upper band uniformly brown, lower band either uniform or with 10–18 pigment intensifications along its length so that band appears spotted; lower band narrow and without spots on caudal peduncle, and extends to rear edge of caudal fin as a streak covering middle caudal ray; upper band becomes narrow posteriorly and disappears below last soft dorsal ray; upper surface of caudal peduncle whitish; entire ventral half of head and body silvery white, unmarked; dorsal fin hyaline for basal two-fifths, then a broad submarginal brown band, with distal edge of fin white; caudal fin white except for median brown streak and scattered brown pigment spots at tips of outermost rays; pectorals hyaline; pelvics white; basal fourth of anal fin hyaline, then a broad submarginal brown band, with distal edge of fin white; upper two-thirds of iris blackish, lower third silvery white. Some variability has been noted with respect to spotting along the lower lateral band. The dark pigment ranges from golden brown to brownish black, and pigment intensifications may be either lacking, poorly defined and not countable, or fairly distinct and numbering from 10 to 18.

Color after twenty hours preservation in formalin. (Based on holotype and one paratype.) Upper half of head and body brownish black, lower half white; line down midline of head and line separating dark area into lengthwise bands bluish green; area around mouth yellowish green (holotype), faintly yellow (paratype); dorsal and anal transparent, yellowish, with a broad submarginal brown band; caudal transparent, tinged with yellow, outer rays somewhat dusky, median ray brown and bordered with yellowish white; pectoral transparent, colorless; pelvics white.

ECOLOGY: Of the 11 known specimens of *R. goslinei* specific habitat data can be given for only 4. These were taken with rotenone at depths of 3–5 feet along rocky seashores where there was some sand bottom and where water circulation was good. Another specimen was taken from a reef near Mokuleia, Oahu, presumably at a similar depth. The six remaining specimens were recovered from the stomachs of large fish, five being from dolphins (*Coryphaena hippurus*) and one from a yellowfin tuna (*Neothunnus macropterus*). These large fish were caught by trolling near Moku Manu (Bird Island), Kaneohe Bay, Oahu, and their stomachs also contained deep-water

scorpaenids and Anthiinae (family Serranidae), the former being demersal. It is presumed that the ingested *Runula* came from near the bottom and probably from depths considerably greater than those sampled with rotenone. The writer has not seen *R. goslinei* alive, and can make no statements on its behavior.

RELATIONSHIP: *R. goslinei* was originally thought to represent a juvenile stage of *R. tapeinosoma* (Bleeker, 1857: 64) of the East Indies, Micronesia, and the southeast Pacific. It was also found to have striking similarities to *R. ringens* (Vaillant, 1894: 74) of the Pacific coasts of the Americas. A critical examination of all three indicated that *goslinei* was an intermediate between two extremes. On one hand was *tapeinosoma*, occurring up to about 1,800 miles from Hawaii, and on the other, *ringens*, separated from Hawaii by more than 2,500 miles of "East Pacific Barrier," with *goslinei* being a geographical and morphological intermediate. It seems very unlikely that there is gene interchange between these widely separated populations, and their morphological similarities are probably better ascribed to a common ancestry rather than interbreeding.

Table 3 presents meristic data for these three blennies, the discrepancies between numbers of specimens in various categories reflecting the damaged condition of those obtained from fish stomachs. The general tendency indicated in Table 3 is that *tapeinosoma* has the most soft fin rays, *ringens* the fewest, and *goslinei* is intermediate. With regard to size, *goslinei* is a small form, becoming sexually mature at standard lengths of 35–40 mm. and probably not growing much beyond that, while *tapeinosoma* and *ringens* appear to be larger, most specimens ranging from 35–65 mm. in standard length. Color pattern and other differences are summarized in the following key which can be used to separate the three species.

1a. Anal fin transparent, colorless; dorsal soft rays 32–34 . . . . . **ringens**

1b. Anal fin with a submarginal brown band. dorsal soft rays 35–37 (rarely 34).

2a. Submarginal brown band on dorsal and anal fins narrow, about one-half to two-thirds as broad as basal clear part of fins; brown band on sides broken into 15–20 vertically elongate spots, band absent or faint between some spots; anal soft rays usually 30 . . . . . **tapeinosoma**

2b. Submarginal brown band on dorsal and anal fins broad, equal to or up to twice as broad as basal clear part of fins, sometimes clear area completely lacking; brown band on sides of nearly uniform intensity, if spots present they are poorly defined and connected by band; anal soft rays usually 29 . . . . . **goslinei**

Notes on the life coloration of *ringens* (as R. *albolinea*) are given by Herre (1936: 403).

DISTRIBUTION: Thus far, limited to the Hawaiian Islands.

REMARKS: Named *goslinei* in honor of Dr. William A. Gosline of the University of Hawaii.

MATERIAL EXAMINED: *R. goslinei*, holotype and paratypes at USNM; 6 Oahu from fish stomachs at UH; 1 Kauai at POFI.

R. tapeinosoma, 5 Marshall Is. at USNM; 3 Marshall Is. and 5 Gilbert Is. at UH.

R. ringens, 9 Mexico, 1 Costa Rica, 1 Colombia, 1 Ecuador, and 1 Galapagos at USNM.

FAUNAL AFFINITIES

The Hawaiian blennies belong to or are derived from the East Indian faunal group, and of the nine genera here considered, all but *Tripterygion*, *Entomacrodus*, and *Runula* are confined to the Indo-Pacific area. Both *Tripterygion* and *Entomacrodus* occur in the warmer parts of the Atlantic and Indo-Pacific while *Runula* appears to be basically Indo-Pacific but occurs also on the tropical Pacific Coasts of the New World. No genus found in Hawaii is restricted to the Hawaiian area.

On the specific level, about 60 per cent of the blennioid fishes reflect the well-known

endemic nature of the Hawaiian fauna. The distribution of 8 of the 13 species (*Tripterygion atriceps*, *Istiblennius zebra*, *Entomacrodus marmoratus*, *Cirripectus obscurus*, *C. lineopunctatus*, *Enchelyurus brunneolus*, *Runula ewaensis*, and *R. goslinei*) is limited to the Hawaiian chain, Johnston, and Midway islands. One blenny, *Istiblennius gibbifrons*, also occurs at Wake Island, the fish fauna of which is predominantly Marshallese, while two others, *Exallias brevis* and *Cirripectus variolosus*, are widespread throughout the Indo-Pacific. Of the remaining two, *Omobranchus elongatus* is wide-ranging in the Indo-Pacific but probably artificially introduced into Hawaii, while *Ecsenius hawaiiensis* is known only from the Hawaiian Islands but under rather peculiar circumstances.

A summary of the distribution of the closest relatives of the endemic Hawaiian blennioids is presented in Table 5. Although distributional pathways are not evident from this table the data tend to fall into several geographical categories, the location of which relates species affinities to the direction of flow of ocean currents. In the first group are wide-ranging species such as *I. edentulus*, *E. epalzeocheilos*, and *R. tapeinosoma;* the second is composed of western Pacific and Indian Ocean forms (*E. bicolor* and *R. rhinorhynchos*); the third of central Pacific species (*T. hemimelas*, *Istiblennius* sp., and *C. quagga*); the fourth of species from the southeastern Pacific (*Cirripectus* sp. from Easter Island, *E. ater*); the fifth of a form from the extreme eastern Pacific (*R. ringens*), and the last of a species from Lord Howe Island (*C. alboapicalis*).

It seems likely that the clockwise current systems north of the Equator have carried some East Indian blennies to southern Japan, Hawaii, and tropical Pacific America, and that the North and South Equatorial Currents have distributed these forms, or their derivatives, to the Marshall and Caroline Islands and to Easter Island, Tahiti, and Samoa. Further distribution in the central Pacific could be effected by local currents or by "island hopping" in areas where atolls are closely spaced. Isolation and other factors acting on variously dispersed stocks has led to their divergence on the specific or infra-specific level.

TABLE 4
MEASUREMENTS, EXPRESSED IN THOUSANDTHS OF THE STANDARD LENGTH, MADE ON CERTAIN HAWAIIAN BLENNIIDAE

	Cirripectus lineopunctatus			*Runula goslinei*		
	HOLOTYPE	PARATYPE	PARATYPE	HOLOTYPE	PARATYPE	PARATYPE
Standard length (mm.)	59.0	69.0	62.6	42.7	37.7	37.2
Head length	280	284	277	223	236	248
Greatest depth of body	280	316	247	145	130	126
Least depth of body	119	106	112	80	74	78
Postorbital length of head	186	194	190	105	111	118
Eye diameter	63	61	67	70	72	65
Snout length	92	97	85	47	53	65
Fleshy interorbital	34	30	32	68	74	70
Least distance between eye and nuchal fringe	115	115	115	...	...	...
Longest dorsal spine	278	184	307	91	109	100
Longest dorsal soft ray	186	197	200	96	122	108
Longest soft anal ray	142	130	136	91	111	108
Longest pectoral ray	203	219	195	127	122	137
Longest pelvic ray	149	145	133	122	159	156
Longest caudal ray	237	235	228	180	175	186
Snout tip to anus	508	528	493	429	419	437
Snout to dorsal origin	272	295	303	169	204	210
Length anal base	449	385	449	491	488	525
Sex	♂	♀	♂	♀	?	?

TABLE 5
DISTRIBUTION OF CLOSEST RELATIVES OF ENDEMIC HAWAIIAN BLENNIES

HAWAIIAN SPECIES	CLOSEST RELATIVE	DISTRIBUTION OF CLOSEST RELATIVE
Tripterygion atriceps	*T. hemimelas*	Phoenix and Samoan Islands
Istiblennius zebra	*I. edentulus*	Entire Indo-Pacific
Istiblennius gibbifrons	*Istiblennius* sp.*	Marshall, Gilbert, and Phoenix Islands
Entomacrodus marmoratus	*E. epalzeocheilos*	East Indies, India, Ceylon, Samoa
Ecsenius hawaiiensis	*E. bicolor*	East Indies, India, Burma, Red Sea, Formosa, New Hebrides, Caroline Islands
Cirripectus obscurus	*C. alboapicalis*	Lord Howe Island
	Cirripectus sp.	Easter Island
Cirripectus lineopunctatus	*C. quagga*	Marshall, Gilbert, Phoenix, and Wake Islands, Samoa
Enchelyurus brunneolus	*E. ater*	Tahiti, Samoa
Runula ewaensis	*R. rhinorhynchos*	East Indies, Philippines, East Africa, Caroline Islands
Runula goslinei	*R. tapeinosoma*	East Indies, East Africa, Caroline, Marshall, Society, and Samoan Islands
	R. ringens	Pacific coasts of Americas

*To be described in the second volume of the "Bikini Reports" of Schultz *et al.*

The close similarity between species with great geographical separation, such as *E. brunneolus* and *E. ater*, or *R. goslinei*, *R. ringens*, and *R. tapeinosoma*, is explicable on these grounds, the major supposition being the ability of migrants to withstand a pelagic journey. Confirmative evidence for this ability is available from data derived from high-seas plankton collections made by POFI. Large blenny larvae are considerable components of some collections, and it is significant that the genus *Tripterygion* has been taken 285 miles from land in the vicinity of the Line Islands, and that *Aspidontus* (closely related to *Runula*) occurred about 110 miles from land in the same area. Specimens of *Istiblennius* and *Cirripectus* were found as much as 15 miles offshore, with other genera appearing closer inshore. The fact that these larvae were large (of sizes equal to or only slightly smaller than juveniles) suggests that their pelagic welfare had been good, and that an open sea life was normal.

It is difficult to explain the maintenance of Hawaiian endemism if the influx and egress of larvae occurs at the appreciable rate suggested by the number of specimens in plankton collections. The occurrence of *I. gibbifrons* at Wake Island may represent the beginnings of a breakdown in Hawaiian endemism, and the single-specimen records of other species mentioned in the introduction may similarly represent stragglers from remote areas.

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Pacific Ferns Described in Nightingale's *Oceanic Sketches*

FRANCIS BALLARD[1]

THIS PAPER has been written as a direct result of an enquiry by Professor Harold St. John of the University of Hawaii. The information obtained was felt to be of sufficient interest to present to a wider audience, especially as it involves the identity of certain species of ferns from the Southern Pacific described by W. J. Hooker in a little-known work on oceanic travel.

The book in question was written by Sir Thomas Nightingale, an English gentleman about whom little seems to have been recorded in the usual books of reference. A search made in the Hooker letters at Kew has failed to produce any correspondence between Nightingale and Hooker, and the Dictionary of National Biography is equally reticent.

However, *Oceanic Sketches* appeared in 1835, being an account of a journey extending over nearly two years to various islands in the South Pacific as well as to Chile and Peru. It is stated that the expedition was undertaken partly for scientific reasons and we know that the author made a collection of dried plants during his wanderings.

Appended to the narration of his travels is a six-page supplement written by Sir William Jackson Hooker, at that time Dr. Hooker, on the ferns, 29 species in all, collected by Nightingale. Of these, five were described as new; as the specimens appear never to have been critically examined, the following observations may be of interest.

Since *Oceanic Sketches* is a somewhat rare work, Hooker's descriptions and observations are reproduced verbatim as follows.

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12. Aspidium ? *Amoa, n. sp.* tota pubescens, frondibus pinnatis, pinnis alternis oblongis obtusiusculis sessilibus membranaceis ad apicem serrulatis, basi truncatis, sursum breviter auriculatis, soris . . . .

Allied in general appearance, to *Asp. exaltatum* and *biserratum*, but the frond is all over downy, especially the stipes, rachis, and midrib. There is, unfortunately, no fructification on the specimens, which is, however, probably marginal. "Amoa" is marked as the native name of the plant.

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21. Lindsaea *propinqua, n. sp.*; fronde bipinnata, pinnis subquinque patentibus, pinnulis oblongo-trapeziformibus margine superiore crenato-lobatis, infimis cuneiformibus, soris fere exacte marginalibus interruptis.

The species most nearly allied to this is the West Indian *L. trapeziformis* of Dryander; but in that, the pinnules are entire, and the sori continuous. The *L. trapeziformis*, again, of Langsdorff and Fischer, (from Brazil) has the sori interrupted, as in our plant, but, at the same time, placed considerably within the almost entire margin of the pinnules.

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26. Alsophila ? *polypodioides, n. sp.*; fronde bipinnata, pinnulis oblongo-lanceolatis attenuatis sessilibus crenato-pinnatifidis, lobulis unisoriferis, rachibus valde pilosis, stipite aculeato.

This is probably, a tall-growing tree-fern, of which the fronds are considerably different from any species with which I am acquainted. The stipe is rather stout, rough, with very short prickles below. Primary pinnae almost opposite, 6–8 inches long, much attenuated at the apex, as are the secondary ones: these latter bear pinnules, which are quite sessile and adnate, but not decurrent, 6–8 lines long, tapering upwards, hairy in the younger parts, crenato-pinnatifid, the crenatures, or lobules, bearing a sorus, which occupies nearly the whole space between the margin and the centre, and is totally destitute of involucre, but evidently inserted at the forking of a nerve. The rachis is every where clothed with rather long patent hairs, some of which are chaffy. The narrow pinnules, singularly incurved at the margins, and long attenuated extremities, are very characteristic of this species.

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27. Trichomanes *glauco-fuscum*, n. sp.; fronde subovata bipinnatifida, laciniis linearibus bi-trifidis obtusiusculis, marginibus integerrimus pallidioribus, involucris paullo ante apicem laciniarum brevium insertis cylindraceis, ore integerrimo dilatato, stipite elongato gracili.

The fronds are ovate, 2–3 inches long, twice shorter that the slender stipes, and remarkable, in the dry state, for a brown colour tinged with a grayish bloom, and if the plant be held between the eye and the light, the margin will be seen to be paler than the centre of the laciniae.

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29. Hymenophyllum *polyanthum*, n. sp.; alatum, rigidum, fronde lanceolata pinnata, pinnis profunde bipinnatifidis, laciniis attenuatis integerrimis obtusis, involucris copiosis axillaribus lato-urceolatis nitidis, ore valde membranaceo dilatato obtuse bilabiato, stipite rachique (superne alata excepta) setosis.

This is certainly one of the finest species of this beautiful genus; a foot and a half long, stout and rigid, opaque, of a dark, almost blackish green colour; the upper half abundantly furnished with axillary, conspicuous, glossy, very membranaceous involucres.

I have been able to find the type specimens of the five novelties in the Kew collections without much difficulty. They are here considered in order.

Aspidium ? amoa Hook.

The specimens were collected in Tahiti and the sheet is written up in Hooker's own hand. It is quite obviously a sterile specimen of a *Nephrolepis*, the largest frond being 23 cm. long and 5 cm. wide. It has the appearance of a young sporeling with herbaceous translucent fronds. Although the plant is described as "tota pubescens," it has only a sparse development of narrow, reddish brown hair-like scales on the rachis and the pinnae are almost glabrous. It may possibly be *Nephrolepis hirsutula* (Forst.) Pr. or even *N. exaltata* (L.) Schott *sens. lat.*

Lindsaea propinqua Hook.

The specimen, collected in Samoa, consists of two fronds, one sterile, one fertile, but no rhizome. It is figured in Hook., Sp. Fil. 1. 223 (1846) t. LXVI. B., the drawing being almost photographic in its accuracy.

The pinnae, 5 or 7, are from 4 to 4.5 cm. wide and are imparipinnate; they do not perceptibly taper upwards. There are from 7 to 13 pairs of pinnules per pinna.

C. Christensen in his Index Filicum reduced the species to "*L. decomposita* Willd. var." This species is usually regarded as an aggregate, and C. Christensen in his revision of the Pteridophyta of Samoa (1943) recognised three forms in Samoa. *Lindsaea propinqua* Hook., however, does not fit any of these. All three agree in possessing linear-lanceolate pinnae with 20 or more pinnules which taper gradually upwards. They are 2–3 cm. (rarely more) wide.

In the circumstances, it would seem wiser at present to retain *L. propinqua* Hook. as a distinct species.

Alsophila ? polypodioides Hook.

There are two sheets of this. One bears the words "S. Sea Islands" in addition to the name; the other, just "Society Islands."

Both are *Thelypteris leucolepis* (Pr.) Ching (*Dryopteris leucolepis* [Pr.] Max.) and not *D. ornata* (Wall.) C. Chr. as stated in C. Chr., Ind. Fil.

Trichomanes glaucofuscum Hook.

On a sheet of mixed collections there are two small fronds corresponding to Hooker's description and a caption above it in Hooker's writing, "Pacific Isles, Nightingale." The specimens are obviously *T. pallidum* Bl.

Hymenophyllum polyanthum Hook.

This species was figured as *Trichomanes polyanthum* Hook. in Hook., Ic. Pl. t. 703 from Nightingale's specimen. The locality given is "Pacific Isles" and Copeland (*in litt.*) has suggested Huahine, though this presumably is guesswork. The original sketches for *t.* 703 are drawn by Hooker on the sheet. Copeland regards the species, under *Trichomanes*, as distinct.

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A Revision of the Pediculate Fishes of the Genus *Malthopsis* Found in the Waters of Japan (Family Ogcocephalidae)

AKIRA OCHIAI and FUMIO MITANI[1]

FISHES of the genus *Malthopsis* are for the most part rarely caught and little known. Since the genus was erected by Alcock in 1891 for the accommodation of *Malthopsis lutea*, about twelve species have been described by several authors from the Indo-Pacific region. From Japanese waters, Jordan (1902: 378–379) described a new species, *Malthopsis tiarella*, based on a specimen taken from Suruga Bay, when he revised the pediculate fishes or anglers of Japan. Then, Tanaka reported two new species, *Malthopsis annulifera* (1908: 44) and *Malthopsis kobayashii* (1916: 348) from the Bay of Sagami and Ise (?), respectively. Subsequently, the occurrence of *Malthopsis mitrigera* Gilbert and Cramer and *Malthopsis lutea* Alcock were reported by Kamohara (1936*a:* 22; 1936*b:* 935) on the basis of specimens obtained from Tosa.

The classification of the group, which has been based on rather unstable morphological features of these fishes, is still far from being satisfactorily understood. For instance, *M. annulifera* and *M. kobayashii* have been synonymized with *M. tiarella* by Tanaka (1931: 43) and also by Kamohara (1934*a:* 194–195; 1934*b:* 1202); further, *M. mitrigera*, *M. tiarella*, *M. annulifera*, and *M. kobayashii* have been united with *M. lutea* by Kamohara (1937*a:* 13; 1937*b:* 119–121). On the other hand, Okada and Matsubara (1938: 458–459), although agreeing in general with Kamohara's treatment, have separated *M. mitrigera* from *M. lutea*. Recently, Kamohara (1950: 277–278; 1952: 103–104) altered his previous view and distinguished the four species based on the general form of the subopercular spine and the number of dorsal fin rays.

Lately the present authors have examined a rather large number of specimens, which are referable to the genus *Malthopsis*, taken by deep-sea trawlers off the Pacific coast of Japan at a depth of about 100 fathoms and deposited in the Department of Fisheries, Faculty of Agriculture, Kyoto University. We have finally come to the conclusion that they represent five distinct species, *M. mitrigera*, *M. annulifera*, *M. lutea*, *M. tiarella*, and *M. jordani* Gilbert, the last of which has never been obtained from Japanese waters.

In this paper, the body length is indicated by a measurement from the tip of the lower jaw to the base of the caudal fin; the disk length is measured from the tip of the lower jaw to the vent; the greatest breadth of the disk is recorded as a distance between the outermost points of the most prominent subopercular spines; the tail width is measured at the beginning of the anal fin; and the rostral spine length is the distance from its tip to a line drawn across the anterolateral sides of the disk as in Figure 1. In order to determine the size of the dark ring-like mark-

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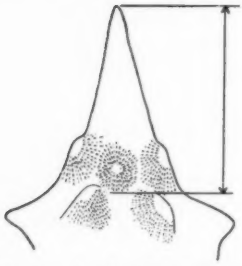

FIG. 1. Diagram showing the measurement used as the length of the rostral spine.

ings, the area of a marking at the right side of the disk and nearest to its midline, is calculated by the planimeter. Teeth are cleared in potassium hydroxide and stained with alizarine red.

We wish to express our sincere gratitude to Professor Kiyomatsu Matsubara for his kind supervision during the course of this study. We are also greatly indebted to Dr. Yaichiro Okada and Mr. Kiyoshi Suzuki for their kindness in sending us several valuable specimens taken from the Kumano Nada. The expenses for executing the studies of the present series were defrayed from the research fund of Kyoto University by Keizo Shibusawa from 1943 to 1945 and by the Ministry of Education from 1950 to 1953.

SYSTEMATIC SIGNIFICANCE OF VARIOUS BODY CHARACTERS

FIN RAYS: The rays in the dorsal and pectoral fins differ in number in certain cases, and are of some importance in the classification of the species of *Malthopsis* (Table 1). The counts of dorsal rays are generally 5 in *M. mitrigera*, *M. annulifera*, and *M. lutea* and 6 in *M. jordani* and *M. tiarella* (in holotypes of *M. jordani* and *M. tiarella* this count is 6 and 7, respectively). The count of pectoral rays is 11–13 and usually 12 in *M. annulifera*, *M. lutea*, and *M. tiarella*, but the count is generally 13 in *M. jordani* and 13–15 in *M. mitrigera*.

MARKINGS: Color markings on the upper surface of the disk are valuable in distinguishing some of the species of *Malthopsis* (Table 2). There are no discernible markings in specimens of *M. mitrigera*. Irregular blackish brown specks are found in *M. tiarella*. About half of our specimens of *M. jordani* and *M. lutea* are unmarked, while the others in each of these species are provided with blackish ring-like markings on each side of the median line of the disk. In the specimens of *M. annulifera*, 5–12 ring-like markings are present on the dorsal surface of the disk. The intraspecific variability of the size of ring-like markings is rather prominent, but it is evident from Figure 2 that the relative size of marking at a given standard length is largest in the specimens of *M. lutea*. The markings are larger in *M. annulifera* than in *M. jordani*.

DERMAL OSSICLES: The surface of the body is completely covered with dermal ossicles. Some of these are enlarged and tubercular in shape and are herein called bony tubercles. In this paper we have taken up the arrangement of bony tubercles on the dorsomedian portion of the disk. A row of the tubercles set on the median line of the upper surface of the disk is the so-called median row. Rows

TABLE 1
DORSAL AND PECTORAL FIN RAY COUNTS IN FIVE SPECIES OF MALTHOPSIS FROM JAPAN

SPECIES	DORSAL FIN RAYS			TOTAL	PECTORAL FIN RAYS					TOTAL
	4	5	6		11	12	13	14	15	
M. mitrigera	1	5	..	6	..	..	2	3	1	6
M. jordani	..	3	4	7	..	1	5	1	..	7
M. annulifera	2	23	..	25	1	19	6	..	..	26
M. lutea	..	32	2	34	4	30	..	..	..	34
M. tiarella	..	..	2	2	..	2	..	..	..	2

of the tubercles running backward from the postorbital rim to a tubercle of the median row are named mediolateral rows. The number and size of the tubercles of these rows, and the point of junction of the median row and the mediolateral rows, are the most valuable characters in the taxonomy of this group.

Particular attention, hitherto, has not been paid to the dermal ossicles on the ventral surface of the disk, but we have found that the mode of their arrangement and their relative size are useful for the classification of this group, though such features are somewhat unstable.

SUBOPERCULAR SPINE: Attention is drawn to the direction of protrusion of the subopercular spine and the number and direction of the prominent spinules at the tip.

CIRRI: So far as descriptions and figures of the fishes of this group are concerned, the dermal cirri which are present on the outer sides of the body have never been noted by any researchers. We have carefully observed material in the water, and consequently we have found that some of the specimens in *M. annulifera* and *M. lutea* are provided with very feeble cirri on the outer side of the body. We cannot tell for certain whether or not the other three species of this group have the cirri, for they are very feebly developed and might be torn off at the time of preservation.

SIZE: Absolute size of the body is an important taxonomic feature. *M. jordani* is the largest form in this group, reaching 140 mm. in total length, and even the smallest specimen we have observed is nearly 100 mm. in entire length. *M. mitrigera*, *M. lutea*, and *M. tiarella* are much smaller and even the largest specimen is not more than 100 mm. On the other hand, *M. annulifera* is moderately large and attains a total length of 118.5 mm., based on our observations.

DISTRIBUTION: The fishes of this group, in general, are rather rare in Japan. Although they are very frequently taken by motor trawlers on the Pacific coast of middle and southern Japan, they have never been obtained from either northern Japan or the Sea of Japan. Of the species, *M. annulifera* and *M. lutea* are commoner than the others. It is assumed that these two species may presumably be living in similar ecological conditions, because in many cases thay are obtained together. *M. jordani* and *M. mitrigera*

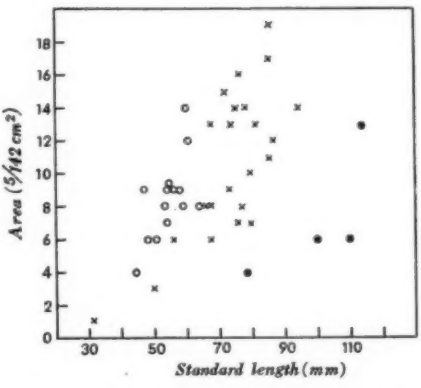

FIG. 2. Relation between standard length and the size of ring-like marking in three species of *Malthopsis*. ○, *M. lutea*; ×, *M. annulifera*; ●, *M. jordani*.

TABLE 2
FREQUENCY DISTRIBUTION OF THE NUMBER OF RING-LIKE MARKINGS ON THE DORSAL SURFACE OF THE DISK IN FOUR SPECIES OF MALTHOPSIS

SPECIES	NUMBER OF MARKINGS PRESENT												
	0	1	2	3	4	5	6	7	8	9	10	11	12
M. mitrigera	7	..	..	..	..	..	..	..	..	..	..	..	..
M. jordani	3	..	2	..	1	1	..	..	..	..	..	..	..
M. annulifera	..	..	..	..	..	3	7	8	4	2	..	..	2
M. lutea	16	..	5	1	3	..	3	1	3	..	..	..	..

are rare, although specimens of these species are frequently obtained with those of *M. annulifera* and *M. lutea*. *M. tiarella* is very rare and we have been favored with only two specimens taken from off Owasi and Kôchi. The specimens of this group taken off Owasi on January 19, 1937, by K. Matsubara contained four different species but not *M. annulifera*.

TAXONOMY

KEY TO THE SPECIES OF *Malthopsis*

1a. Subopercular spine greatly produced laterally, bearing 4 obvious spinules, 2 of them directed forward and 2 backward; ventral surface of disk covered with radially striated bony tubercles as large as those of dorsal surface; band of vomerine teeth elongated transversely, rectangular; peritoneum dusky; tail very slender, the width usually more than 10.0 in standard length; dorsal surface of disk without markings . . . . . **mitrigera**

1b. Subopercular spine neither greatly protruding outward nor ending in 4 obvious spinules, antrorse spinule either single or wanting; ventral surface of disk covered with minute tubercles; the patch of vomerine teeth rather quadrangular; peritoneum pale; tail moderately thick, the width usually less than 10.0 in standard length; dorsal surface of disk with or without markings 2

2a. Subopercular spine directed outward with a projecting antrorse spinule at the tip; ventral surface of disk sparsely covered with rather small bony tubercles 3

2b. Subopercular spine directed outward and backward, forming a triangular process, without a projecting antrorse spinule at the tip; ventral surface of disk thickly covered with minute bony prickles 4

3a. Bony tubercles on dorsal surface of disk pointed and but slightly granulated, forming 3 rows on forehead; mediolateral rows of tubercles joined to median row at posterior portion of disk; bony tubercles lying between vent and pelvic fins continuous . . . . . **jordani**

3b. Bony tubercles on dorsal surface of disk rather pointed and noticeably granulated, forming 2 rows on forehead; mediolateral rows joined to median row at anterior portion of disk; bony tubercles lying between vent and pelvic fin few, scattered . . . . . **annulifera**

4a. Bony tubercles on dorsomedial surface forming 3 or more rows on forehead; dorsal surface of disk with or without ring-like markings; dorsal rays usually 5 . . . . . **lutea**

4b. Bony tubercles on dorsomedial surface forming 2 rows on forehead; dorsal surface of disk without ring-like markings, but with scattered blackish brown specks; dorsal rays 6 or 7 . . . . . **tiarella**

Malthopsis mitrigera Gilbert and Cramer

Kagi-furyu-uo (Japanese name)

Figs. 3, 4

Malthopsis mitrigera Gilbert and Cramer, 1896: 434–435, pl. 48, figs. 1–2; Jordan and Evermann, 1905: 524–525, fig. 229: Gilbert, 1905: 695; Fowler, 1934: 450; Kamohara, 1936*a*: 22; Okada and Matsubara, 1938: 458; Kamohara, 1950: 287; Kamohara, 1952: 103.

Malthopsis triangularis Lloyd, 1909: 169, pl. 45, figs. 1–1a; Barnard, 1927: 1009; Smith, 1949: 427, fig. 1227.

Malthopsis lutea (*partim*) Kamohara, 1937*a*: 13, pl. 2, fig. 5.

MATERIAL EXAMINED: Nos. 4156, 4157, 4162, 4165, 4930, and 4932 (the numbers refer to Matsubara's Fish Collection), 29.0–61.0 mm. in standard length (32.0–74.0 mm. in total length), off Owasi, Mie Pref., January 19, 1937; No. 15169, 73.0 mm. (86.5 mm.) off Owasi, January 18–20, 1950.

D. 4–5; A. 4; C. 9; P. 13–15; V. 1, 5. Disk length 1.79–1.98 (1.85) in standard length; disk width 1.04–1.26 (1.12); tail width 10.20–

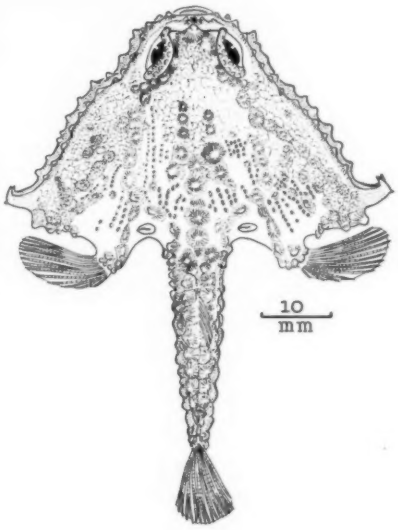

FIG. 3. Dorsal aspect of *Malthopsis mitrigera* (specimen no. 4157, 58.0 mm. in standard length).

13.22 (11.15). Disk width 0.55–0.71 (0.61) in disk length; eye diameter 3.37–4.60 (4.05); interorbital width 4.25–6.30 (5.21); rostral spine 8.40–10.80 (9.51); mouth width 2.84–3.72 (3.47); pectoral fin 1.98–2.60 (2.32); pelvic fin 2.31–3.54 (2.70).

Disk very broad, the greatest width slightly less than the length of body. Tail slender and short. Rostral spine nearly vertical or directed somewhat obliquely upward, the length nearly equal to or less than half the diameter of eye.

Dorsal surface of disk thickly covered with many dermal ossicles except for both opercular and shoulder regions; some of them enlarged and quite regular in their arrangement; radial striations of bony tubercles minute, smooth, but finely serrate when viewed through a lens (Fig. 4c); mediolateral rows each represented by 2 or 3 rather prominent tubercles; median row of tubercles beginning at the middle part of disk, leaving therefore a rather smooth space along the median line of forehead; each side of the first tubercle on median row armed with 1 or 2 noticeable tubercles. Three rows of tubercles running along the anterolateral margin of disk, the upper row beginning at the posterodorsal part of upper jaw and bending slightly upward at the under side of posterior rim of orbit. Bony tubercles on ventral surface enlarged and in contact with each other; vent in center of a naked area of skin, surrounedd by an elliptical basin with several tubercles; a double row of tubercles runs from base of pectoral fin to base of pelvic fin; an enlarged tubercle in front of pectoral fin, surrounded by several smaller ones; small dermal ossicles, moreover, scattered irregularly on thoracic region (Fig. $4A_1$, A_2). Rest of ventral surface of disk naked. Tail completely surrounded with large bony tubercles.

Subopercular spine flattish, strongly protruding, bearing 4 obvious spinules at the tip, 2 of these distinctly directed forward, the other ones variable in size but smaller and directed outward and backward (Fig. $4B_2$); in young specimens, however, the spine is not so strongly protruded as in adults (Fig. $4B_1$).

Sides of body without dermal cirri. Longest anal ray usually not reaching to base of caudal when the fin is laid back.

Band of vomerine teeth elongated laterally in form of rectangle (Fig. 4E); patch of teeth on palatine rather small and circular (Fig. 4E); teeth on tongue in 2 broad parallel bands, their posterolateral regions not divergent (Fig. 4D).

Color, in formalin, uniformly yellowish brown above, without any markings; pale beiow; fins also pale; peritoneum dusky.

REMARKS: Our specimens thus far examined agree well with the original description of this species given by Gilbert and Cramer (1896: 434–435, pl. 48, figs. 1–2), except for the more numerous branchiostegal rays (5 instead of 4) and somewhat shorter tail. *Malthopsis triangularis* Lloyd (1909: 169, pl. 45, figs. 1–1a) should be included in the synonymy of this species inasmuch as there is no obvious difference which will enable us to distinguish

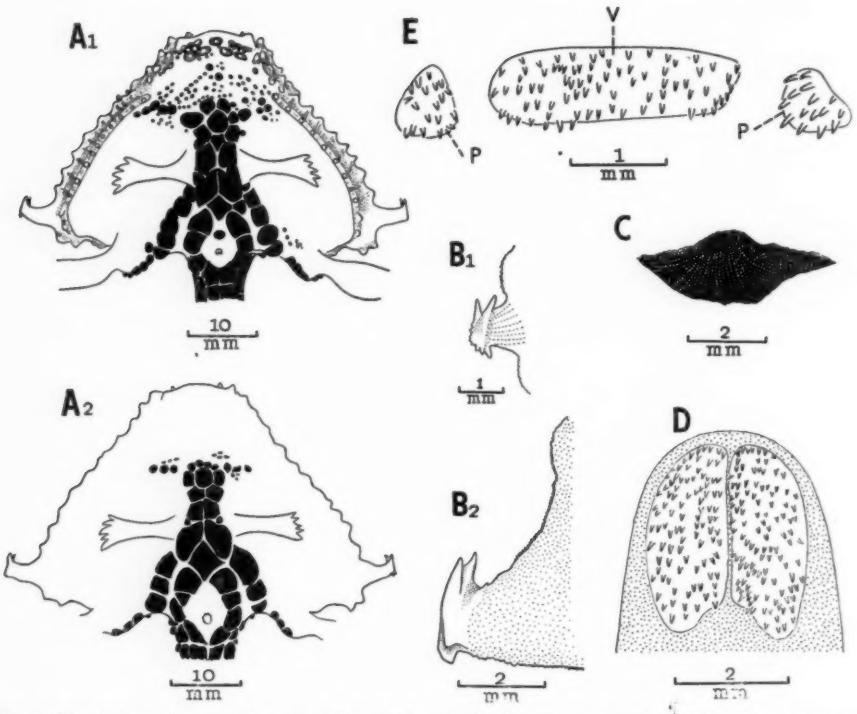

FIG. 4. *M. mitrigera:* A_1, ventral aspect of disk; A_2, bony tubercles on ventral surface of disk; $B_{1,2}$, subopercular spine of young and mature specimens; C, lateral aspect of bony tubercle in median line of dorsal surface of disk; D, dorsal surface of anterior part of tongue; E, teeth on vomer (V) and palatine (P). A_1 drawn from a specimen, 58.0 mm. in standard length (specimen no. 4157); A_2, from a specimen, 55.0 mm. in standard length (specimen no. 4930); B_1, from a specimen, 29.0 mm. in standard length (specimen no. 4932); B_2, C, D, and E, from a specimen 61.0 mm. in standard length (specimen no. 4162).

it. Of the specimens belonging to Lloyd's types (1909: 175–176, pl. 48–49), W (with the arrangement of the dermal armature on body orderly and the disk width medium), X (with the dermal armature orderly and the disk narrow), and Z (with the dermal armature orderly and the disk broad) are all identical with this species.

Malthopsis jordani Gilbert

Kowanuke-furyu-uo (new Japanese name)

Figs. 5, 6

Malthopsis jordani Gilbert, 1905: 695–696, pl. 100; Jordan and Seale, 1906: 438; Böhlke, 1953: 148.

Malthopsis lutea (*partim*) Kamohara, 1937*a:* 13, pl. 2, fig. 4.

MATERIAL EXAMINED: No. 1629, 101.0 mm. (125.0 mm.), off Owasi, Mie Pref., December 6–9, 1935. Nos. 4152 and 4154, 88.5–113.5 mm. (112.0–140.0 mm.), off Owasi, January 19, 1937. No. 6798, 86.5 mm. (108.5 mm.), off Heta, Shizuoka Pref., November 22–24, 1938. No. 19062, 78.5 mm. (98.0 mm.), off Owasi, November 12–17, 1952. Nos. 20513 and 20514, 100.0–110.0 mm. (121.5–135.0 mm.), off Miya, Aichi Pref., April 8, 1953.

D. 5–6; C. 8–9; P. 12–14; V. 1, 5. Disk length 1.65–1.79 (1.71) in standard length; disk width 1.29–1.45 (1.37); tail width 7.69–

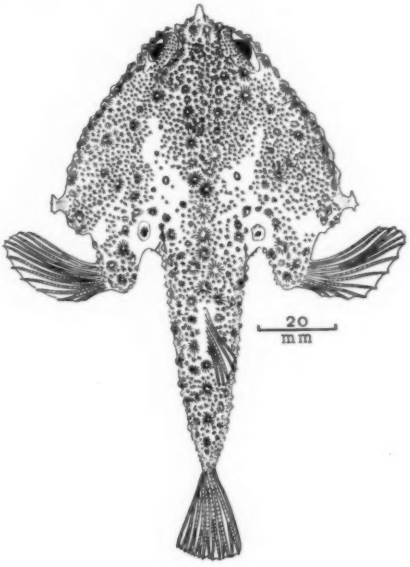

FIG. 5. Dorsal aspect of *Malthopsis jordani* (specimen no. 20513, 110 mm. in standard length).

8.63 (7.99). Disk width 0.77–0.82 (0.80) in disk length; eye diameter 4.28–5.95 (5.03); interorbital width 6.20–8.21 (7.09); rostral spine 8.91–13.70 (10.24); mouth width 3.68–4.46 (4.03); pectoral fin 2.30–3.12 (2.66); pelvic fin 2.46–3.12 (2.66).

Disk broad, the greatest width somewhat less than length of body. Tail rather slender and short. Rostral spine directed forward or forward and slightly upward, nearly half as long as diameter of eye.

Dorsal surface of disk rather thickly covered with dermal ossicles except for both opercular and shoulder regions; some of them enlarged, pointed and quite regular in their arrangement, radial striations of bony tubercles prominent, rather smooth but slightly granulated (Fig. 6C); mediolateral rows each represented by several tubercles, joined to median row of tubercles at posterior portion of disk; median row of tubercles developed throughout the entire length of disk, but the tubercles between those of the mediolateral

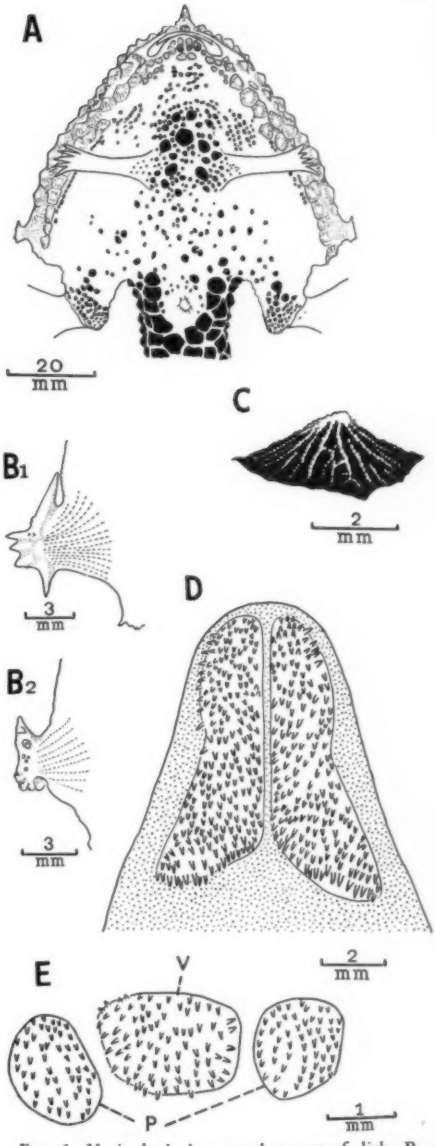

FIG. 6. *M. jordani:* A, ventral aspect of disk; $B_{1,2}$, subopercular spine; C, lateral aspect of tubercle in median line of upper surface of disk; dorsal surface of anterior part of tongue; E, teeth on vomer (V) and palatine (P). A, from a specimen, 110.0 mm. in standard length (specimen no. 20513); B_1, from a specimen, 78.5 mm. in standard length (specimen no. 19062); B_2, from a specimen, 110.0 mm. in standard length (specimen no. 20514); C, D, and E, from a specimen, 86.5 mm. in standard length (specimen no. 6798).

rows scarcely enlarged. Three rows of tubercles running along the anterolateral margin of disk, the upper beginning at the posterior part of upper jaw, and turning sharply upward at the under side of posterior rim of orbit. Ventral surface of opercular region largely smooth, but the other parts with scattered tubercles which are flatter and smaller than those of dorsal surface; several tubercles between pelvics enlarged; small tubercles, moreover, scattered from thoracic to posterior edge of disk (Fig. 6A). Tail completely surrounded with large or small tubercles.

Subopercular spine short, protruding; the tip armed with projecting spinules, one of them prominent, directed forward (Fig. $6B_1$, B_2).

Sides of body without dermal cirri. Longest anal ray reaching to or beyond the base of caudal when the fin is laid back.

Patches of vomerine and palatine teeth rather large, circular or quadrangular (Fig. 6E); teeth on tongue in two broad parallel bands, their posterolateral regions widely divergent (Fig. 6D).

Color, in formalin, yellow above, with or without black ring-like markings (of 7 specimens examined, 4 had 2 or 5 rings, the other 3 had none). Dermal ossicles on back brownish along their base and striations; ventral surface of body pale; a dark band crossing near the end of caudal; pectoral and dorsal dusky; pelvic and anal pale; peritoneum also pale.

Malthopsis annulifera Tanaka
Wanuke-furyu-uo (Japanese name)
Figs. 7, 8

Malthopsis annulifera Tanaka, 1908: 44, pl. 1; Jordan, Tanaka and Snyder, 1913: 428; Kamohara, 1950: 287, fig. 220; Katayama, '1950: 12; Kamohara, 1952: 103–104, fig. 100.

Malthopsis ocellata Smith and Radcliffe *in* Radcliffe, 1912: 207–208, pl. 18, fig. 1, pl. 19, fig. 1.

Malthopsis tiarella (*partim*) Kamohara, 1954*a*: 194–195, figs. 2–3.

MATERIAL EXAMINED: Nos. 1630–1632, 1634 and 1638, 50.0–81.5 mm. (63.0–101.0 mm.), off Owasi, Mie Pref., December 6–9, 1935. No. 2031, 31.5 mm. (40.5 mm.), off Owasi, April 13, 1936. Nos. 4134–4135, 4158 and 4295, 66.0–76.0 mm. (83.5–93.0 mm.), off Owasi, January, 1939. No. 4680, 56.0 mm. (69.5 mm.), off Owasi, December 1936. No. 4916, 94.5 mm. (118.5 mm.), off Owasi, February 3, 1938. No. 15171, 67.5 mm. (84.5 mm.), off Owasi, January 18–20, 1950. No. 17637, 77.0 mm. (95.5 mm.), off Miya, Aichi Pref., March 15, 1952. Nos. 19063–19064 and 19202, 73.0–85.5 mm. (93.5–108.0 mm.), off Owasi, November 12–17, 1952. Nos. 19675 and 19676, 75.0–85.0 mm. (94.0–104.0 mm.), off Nobeoka, Miyazaki Pref., December 10, 1952. Nos. 20515 and 20516, 72.0–76.0 mm. (91.5–93.0 mm.), off Miya, April 8, 1953. No. 20821, 80.0 mm. (101.0 mm.), locality and date unknown. Nos. 21072–21073, 82.0–

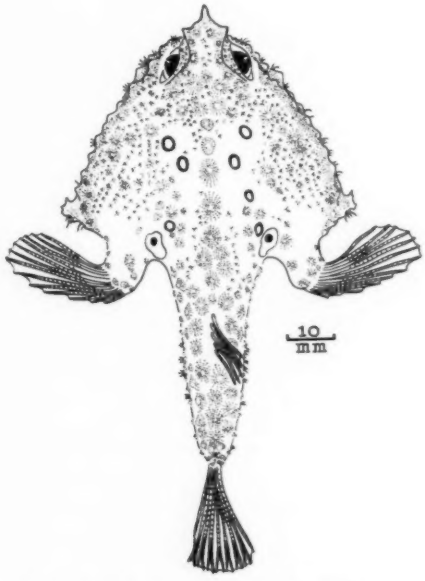

FIG. 7. Dorsal aspect of *Malthopsis annulifera* (specimen no. 19063, 85.5 mm. in standard length).

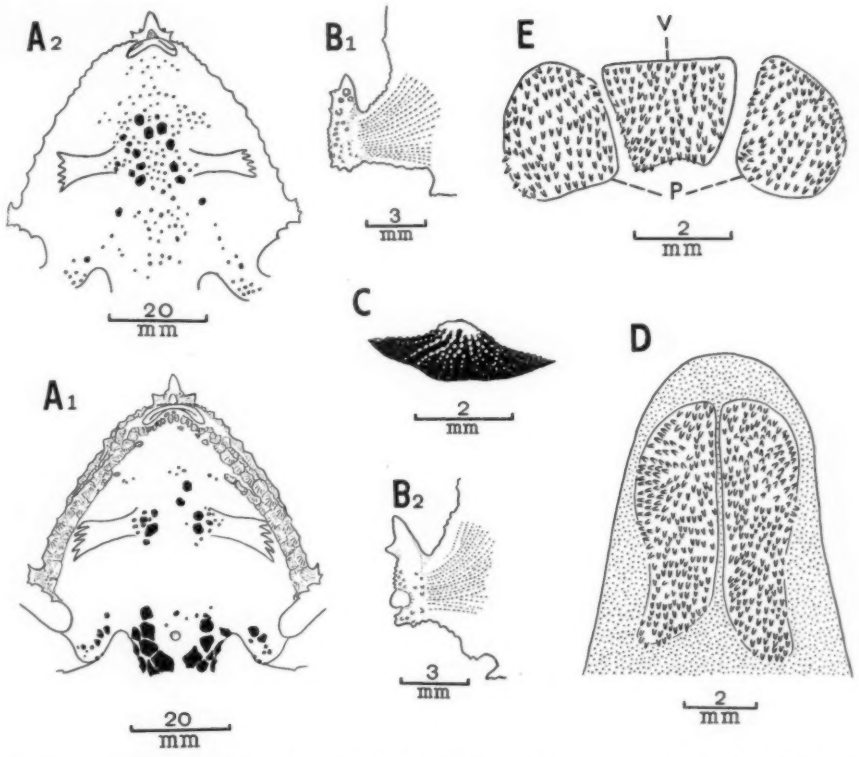

FIG. 8. *M. annulifera:* A_1, ventral aspect of disk; A_2, bony tubercles on ventral surface of disk; $B_{1,2}$, subopercular spine; C, lateral aspect of bony tubercle in median line of dorsal surface of disk; D, dorsal surface of anterior part of tongue; E, teeth on vomer (V) and palatine (P). A_1, from a specimen 85.5 mm. in standard length (specimen no. 19063); A_2, from a specimen, 72.0 mm. (specimen no. 20515); B_1, from a specimen, 77.0 mm. in standard length (specimen no. 17637); B_2, from a specimen, 75.0 mm. (specimen no. 9675); C, D, and E, from a specimen, 79.5 mm. (specimen no. 1630).

90.5 mm. (104.0–112.0 mm.), off Owasi, November 5, 1953.

No. 1993 (the number refers to Mie University Fish Collection) 85.0 mm. (105.5 mm.), off Owasi, September 21, 1950. No. 4421, 87.0 mm. (107.0 mm.), off Owasi, February 1952.

D. 4–5; A. 4; C. 8–9; P. 11–13; V. 1, 5. Disk length 1.73–1.98 (1.88) in standard length; disk width 1.05–1.47 (1.29); tail width 6.66–8.23 (7.37). Disk width 0.58–0.76 (0.68) in disk length; eye diameter 3.81–5.46 (4.86); interorbital width 6.00–8.72 (7.28); rostral spine 5.69–14.83 (9.66); mouth width 3.31–4.54 (3.94); pectoral fin 2.26–3.11 (2.74); pelvic fin 2.57–3.33 (3.05).

Disk broad, the greatest width somewhat less than length of body. Tail rather slender and short. Rostral spine about half as long as diameter of eye, directed forward or slightly upward.

Dorsal surface of disk covered with dermal ossicles except for both opercular and shoulder regions; some ossicles enlarged, moderately pointed, and quite regular in their arrangement; radial striations of bony tubercles prominent, and noticeably granulate (Fig. 8C); mediolateral rows represented by

two rather large tubercles, and joined to median row at anterior portion of disk; median row usually ending behind orbits, leaving a smooth space between orbits; three rows of tubercles running along the anterolateral margin of disk, the upper row turning sharply upward ventral of posterior rim of orbit. Ventral surface largely smooth, but sometimes armed with many ossicles between pelvic fins as in *M. jordani*, some of them enlarged, the tubercles, however, generally flattish and much smaller than those of the dorsal surface (Fig. $8A_1$, A_2). Tail rather sparsely surrounded with large bony tubercles.

Subopercular spine protruding, with a prominent antrorse spinule (Fig. $8B_1$, B_2).

Sides of body with many dermal cirri. Longest anal ray usually does not reach to base of caudal when the fin is laid back.

Patches of vomerine and palatine teeth rather large and roundish or quadrangular in shape (Fig. 8E); bands of teeth on tongue elongate, parallel, their posterolateral regions divergent (Fig. 8D).

Color, in formalin, yellowish brown above, furnished with 5 to 12 rather large black ring-like markings; striations of bony tubercles brown; under side of body pale; caudal and dorsal dusky, but other fins pale; peritoneum pale.

REMARKS: Specimens thus far examined agree in general with the original description of *Malthopsis annulifera* Tanaka (1908: 44), but differ from it in having a larger number of pectoral rays (12–14 instead of 8–9) and pointed bony tubercles on the ventral surface instead of flattish plates. Agreement of our specimens with those of *Malthopsis ocellata* Smith and Radcliffe (1912: 207–208, pl. 18, fig. 1, pl. 19, fig. 1) is evident inasmuch as they accord well with it in important features such as the dermal ossicles on body and the rostral and subopercular spines, but differ in that our specimens are provided with a larger number of anal rays (4 instead of 2).

Malthopsis lutea Alcock
Furyu-uo (Japanese name)
Figs. 9, 10

Malthopsis luteus Alcock, 1891: 26, pl. 8, figs. 2–2a; (*partim*) Okada and Matsubara, 1938: 458, pl. 113, fig. 1; Herre, 1941: 403; Mori, 1952: 195.

Malthopsis luteus (Alcock), Goode and Bean, 1895: 537, fig. 411.

Malthopsis lutea Alcock, 1899: 64–65, pl. 19, fig. 4; Kamohara, 1936*b*: 935; (*partim*) Kamohara, 1938: 76; Kamohara, 1950: 287; Kamohara, 1952: 103.

Malthopsis kobayashii Tanaka, 1916: 348.

MATERIAL EXAMINED: Nos. 976, 1635–1637, 47.0–60.0 mm. (60.5–78.0 mm.), off Owasi, Mie Pref., December 6–9, 1935. Nos. 4132–4133, 4292–4294, 4296 and 4679, 47.0–68.0 mm. (58.0–83.0 mm.), off Owasi, January 19, 1937. Nos. 6799–6802, 43.5–62.5 mm. (54.0–77.0 mm.), off Heta, Shizuoka Pref., November 22–24, 1938. Nos. 7053–7055 and 7075–

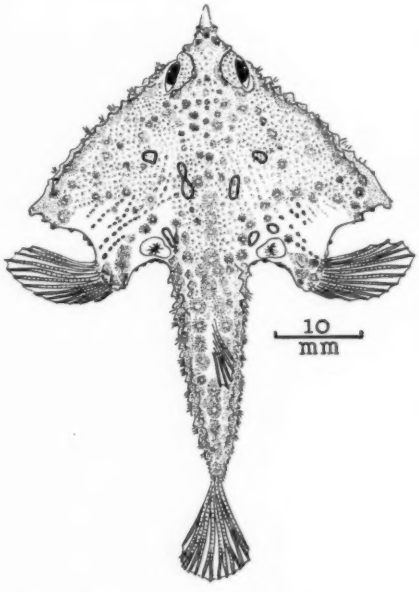

FIG. 9. Dorsal aspect of *Malthopsis lutea* (specimen no. 1637, 47.0 mm. in standard length).

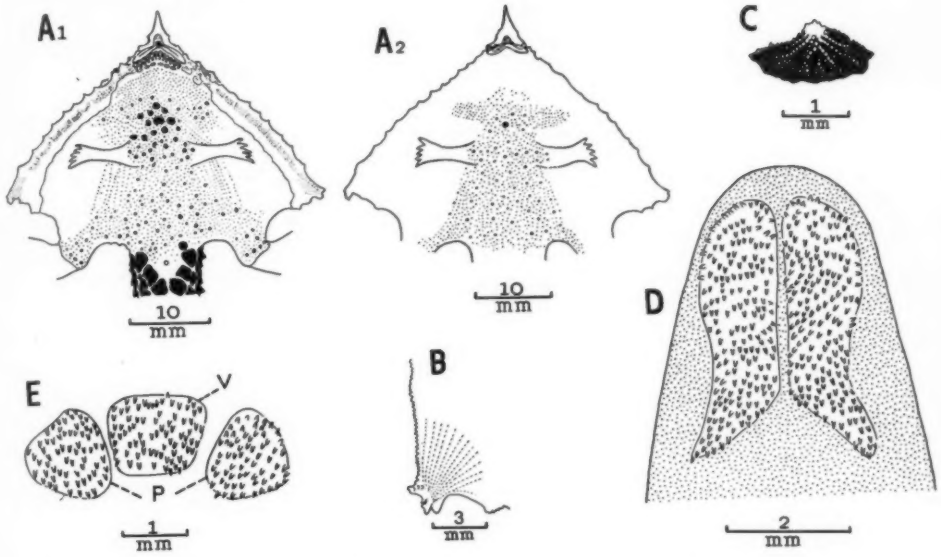

FIG. 10. *M. lutea:* A_1, ventral aspect of disk; A_2, dermal prickles on ventral surface of disk; B, subopercular spine; C, lateral aspect of bony tubercles on median line of dorsal surface of disk; D, dorsal surface of anterior part of tongue; E, teeth on palatine (P) and vomer (V). A_1, from a specimen, 47.0 mm. in standard length (specimen no. 1637); A_2, from a specimen 68.0 mm. in standard length (specimen no. 4294); B, from a specimen 55.0 mm. in standard length (specimen no. 7259); C, D, and E, from a specimen, 59.5 mm. (specimen no. 7054).

7076, 53.5–60.0 mm. (66.0–74.0 mm.), off Heta, November 24–25, 1939. No. 7259, 55.0 mm. (67.0 mm.), off Heta, January 6, 1940. No. 10368, 54.0 mm. (68.0 mm.), locality and date unknown. No. 15170, 60.0 mm. (76.0 mm.), off Owasi, January 18–20, 1950. No. 19201, 47.0 mm. (58.0 mm.), off Owasi, November 12–17, 1952. Nos. 20817–20820, 44.5–55.0 mm. (57.5–70.0 mm.), locality and date unknown. Nos. 21074–21075, 41.0–64.0 mm. (52.5–82.0 mm.), off Owasi, November 5, 1953.

No. 1992 (the numbers refer to Mie University Fish Collection), 62.5 mm. (78.0 mm.), off Owasi, September 21, 1950. Nos. 4420 and 4422–4423, 54.0–62.5 mm. (68.0–76.5 mm.), off Owasi, February, 1952.

D. 5–6; A. 4; C. 9; P. 11–12. V. 1, 5. Disk length 1.65–1.97 (1.79) in standard length; body width 1.08–1.44 (1.29); tail width 6.30–9.64 (7.73). Disk width 0.58–0.81 (0.71) in disk length; eye diameter 3.50–5.55 (4.48); interorbital width 6.79–10.00 (8.31); rostral spine 4.66–8.90 (6.63); mouth width 2.95–4.54 (3.88); pectoral fin 2.18–3.86 (2.73); pelvic fin 2.45–3.74 (2.99).

Disk broad, slightly narrower than length of body. Tail rather slender and short. Rostral spine more than half as long as diameter of eye, directed nearly horizontally forward.

Dorsal surface of disk thickly covered with dermal ossicles except for both opercular and shoulder regions; some ossicles enlarged, pointed and quite regular in their arrangement; radial striations of bony tubercles prominent and noticeably serrate (Fig. 10 C); mediolateral row represented by about 4 rather large bony tubercles and joined to median row of tubercles at the anterior part of disk; median row developed throughout the entire length of disk, but several tubercles between those of the mediolateral row smaller

than the posterior ones; occasionally, a number of tubercles scattered on both sides of mediolateral rows. Three rows of bony tubercles running along the antero-lateral margins of disk, the upper turning obliquely upwardly ventrad of posterior rim of eye. Ventral surface of disk, except for lateral regions, thickly covered with minute dermal prickles, some of them, more or less enlarged (Fig. 10 A_1, A_2). Tail rather completely surrounded with bony tubercles.

Subopercular spine directed outward and backward, armed at the tip with several minute teeth, but without a prominent antrorse spinule (Fig. 10B).

Sides of body with many dermal cirri. Longest anal ray reaches to base of caudal when the fin is laid back.

Patches of vomer and palatine teeth rather large and quadrangular or circular (Fig. 10E); bands of teeth on tongue elongate, parallel, the posterolateral regions greatly divergent (Fig. 10D).

Color, in formalin, yellowish brown above; pale below; striations of dorsal bony tubercles brown; upper surface of disk sometimes furnished with 2 to 8 large ring-like markings; these markings, however, entirely absent in half of our specimens; caudal, pectoral and dorsal dusky, but the other fins pale; peritoneum also pale.

REMARKS: The specimens belonging to the types V (with the arrangement of the dorsal armature on body irregular and the disk width narrow) and Y (with the dermal armature irregular and the disk width medium) of Lloyd (1909: 175–176, pls. 48–49) are contained within this species.

Malthopsis tiarella Jordan
Goma-furyu-uo (Japanese name)
Fig. 11

Malthopsis tiarella Jordan, 1902: 378–379, fig. 7; Jordan and Starks, 1904: 628; (*partim*) Jordan, Tanaka, and Snyder, 1913: 428, fig. 396; (*partim*) Tanaka, 1931: 43; ?Kamohara, 1934*b*: 1202; ?Oshima, 1938: 285; Kamohara, 1950: 288; Kamohara, 1952: 104.

MATERIAL EXAMINED: No. 4679, 51.5 mm.

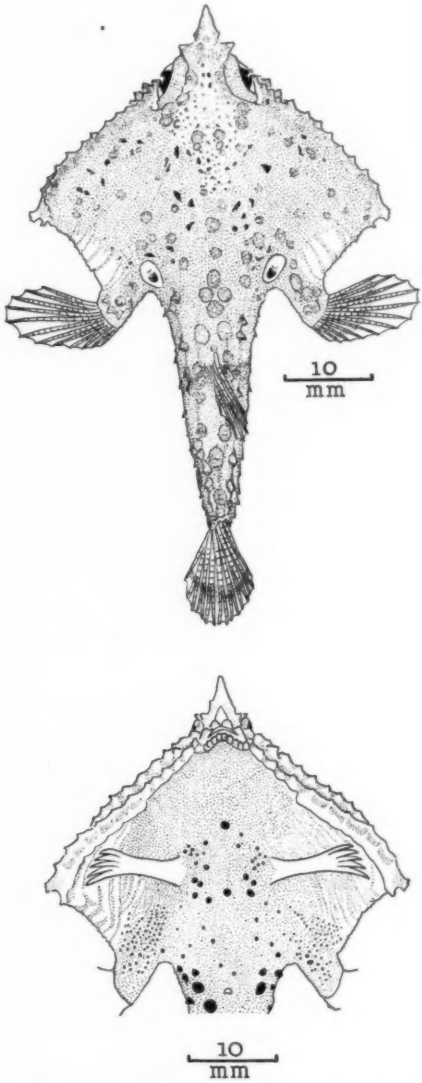

FIG. 11. *Malthopsis tiarella:* Upper figure, dorsal aspect (specimen no. 4679, 515 mm. in standard length); lower figure, ventral aspect of disk (specimen no. 4679, 51.5 mm. in standard length).

(64.5 mm.), off Owasi, Mie Pref., January 19, 1937. No. 22068, 37.0 mm. (47.0 mm.), Mimase, Kôchi City, April 10, 1954.

D. 6; A. 3–4; C. 8–9; P. 12; V. 1, 5. Disk length 1.71–1.76 in standard length; disk width 1.31–1.33; tail width 6.70–7.35. Disk width 0.75–0.76 in disk length; eye diameter 4.20–4.60; interorbital width 6.00–7.92; rostral spine 5.20–6.52; mouth width 4.75–5.00; pectoral fin 1.91–2.85; pelvic fin 2.47–3.08.

Disk broad, but narrower than length of body. Tail rather slender and short. Rostral spine nearly porrect, more than half as long as diameter of eye.

Dorsal surface of disk thickly covered with dermal ossicles except for opercle; some of them enlarged, strongly pointed and regular in their arrangement; radial striations of the tubercles prominent and sharply serrate; mediolateral rows each represented by 2–3 rather large tubercles, joining median row at middle of disk; area of forehead between mediolateral rows without any prominent median tubercles. Three rows of tubercles running along the anterolateral margin of disk, the upper row sharply turning obliquely upward ventrad of posterior rim of orbit; the middle row represented by 4 large tubercles, inconspicuous tubercles scattered between the middle and lower rows. Ventral surface of disk almost entirely covered with minute bony prickles, some of them more or less enlarged (Fig. 11). Tail completely surrounded with large and small tubercles.

Subopercular spine directed outward and backward, armed with several minute serrations, but without any prominent spinules.

Lateral sides of body without dermal cirri. Longest anal ray reaches to base of caudal when the fin is laid back.

Patches of vomerine and palatine teeth rather large and quadrangular.

Color, in formalin, brownish above, with irregular blackish brown specks; back and side of tail crossed with black bars at the base of dorsal and caudal; pale below; a dark bar crossing near the end of caudal; pectoral and pelvic dusky; anal pale.

REMARKS: It should be noted that *Malthopsis tiarella* is shown in Jordan's figure (1902, fig. 7) with more numerous pectoral and caudal rays than those given by Jordan in his original description of this species (14 and 9 respectively instead of 10 and 6). We are inclined to regard these discrepancies partly as Jordan's miscounting and partly as draughtsman's errors. Although the dorsal rays are somewhat fewer in our two specimens than in the holotype (6 instead of 7), the agreement in other various important features between our specimens and the holotype are beyond doubt. The species is most closely related to *Malthopsis lutea* Alcock, but may be distinguished from it by the following features: bony tubercles on dorsal surface forming two rows on forehead; upper surface of disk provided with blackish brown irregular specks; dorsal rays six or seven.

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Description of a New Species of *Elytrurus* and a Catalogue of the Known Species (Coleoptera: Curculionidae: Otiorhynchinae)

ELWOOD C. ZIMMERMAN[1]

SIR GUY MARSHALL has asked me to describe a new species of *Elytrurus* which was collected on Niue Island by A. C. Gerlach and sent to the Commonwealth Institute of Entomology for identification by W. Cottier, Department of Scientific and Industrial Research, New Zealand. I am pleased to describe the new species, because it is the first to be found on the island of Niue, and it thus fills another gap in the knowledge of the distribution of this interesting genus of broad-nosed weevils. Niue (lat. 19° 02′ S, long. 169° 55′ W) lies south of Samoa, and Vavau, Tonga, which is about 240 miles to the west, is the nearest island. Niue is an emerged coral island which rises somewhat more than 200 feet above sea level. The flora is quite varied for a small coral island, and considerable areas of forest remain. It is unfortunate that so little is known about the insect fauna of the island.

With this new species it is appropriate to present a catalogue of *Elytrurus* and append some notes on the geographical distribution of the genus and its relationship to *Rhyncogonus*. In the Pacific east of Samoa, *Elytrurus* is replaced by the genus *Rhyncogonus* the appearance and habits of which are very similar to those of *Elytrurus* (see Fig. 1). In no island, however, do both genera occur together, and the reason for the unusual distributions of the two groups has not yet been discovered. The eastern-most species of *Elytrurus* occur in Samoa, and the Samoan forms are the most divergent of the genus. I have collected several thousand specimens of the two genera, and they appear to be counterparts. The eggs of *Rhyncogonus* are deposited on leaves, and the young larvae drop to the ground to make their way to the roots of plants where they feed. I presume that *Elytrurus* has similar habits, but I did not search for their early stages during my expeditions to Samoa and Fiji.

The new species and *Elytrurus cinctus* Boisduval, to which it is most closely allied, share the character of reduction in the development of the bevel of the corbel of the hind tibia, a tendency toward the formation found in *Rhyncogonus*. In *Rhyncogonus* the bevel is obsolete, and this character has been found useful in separating the two genera. However, it has not been pointed out that there is much variation in the development of the corbel in *Elytrurus*, and without an expert knowledge of the formation of the bevel in these genera, one might easily be led astray. In its most highly developed form the bevel is a prominently differentiated, shiny area set off obliquely or angulately from the outer face of the tibia, and entirely surrounded on the inner

[1] This research was completed at the British Museum (Natural History) during the tenure of a United States National Science Foundation grant, and this paper is a tangent contribution to the project "Insects of Hawaii." Manuscript received August 23, 1955.

FIG. 1. Map showing the distribution of the genera *Elytrurus* ("E") and *Rhyncogonus* ("R").

(tarsal) and outer (ectal face) sides by a dense palisade of stiff spines. In many species of *Elytrurus*, including the new species and *cinctus*, the outer row of bristles has been almost entirely lost. In *Rhyncogonus* there is no trace of the outer palisade of bristles, and at most only the faintest indication of an area which might be interpreted as an indication of the remnant of a bevel can be distinguished in some species. The eyes of *Elytrurus* are larger and flatter than those of *Rhyncogonus*. Many species of *Rhyncogonus* have strongly protuberant eyes.

Marshall (1938: 71) noted of *Elytrurus* that "An exceptional type of dimorphism is to be found in the first segment of the hind tarsi: in the male this segment is clothed beneath with soft hairs; but in the female its inner edge on the basal half is set with stiff spines, which are sometimes bare and sometimes hidden by hairs." This statement appears to apply only to certain species, and it is not characteristic of the genus as a whole.

The adult weevils feed upon the leaves of plants, and many species are abundant and voracious feeders. Plants such as *Piper* are frequently heavily attacked. It is possible that some species may become pests in areas where cultivated crops are grown adjacent to native forests or in clearings in the forest. One species, *griseus*, has become very widespread in the Fijian islands, evidently through the aid of man. Should certain of the species be carried to other regions and become established some damage to economic crops might occur. The larvae are, as noted above, presumed to feed underground at the roots of plants.

The described species of *Elytrurus* are distributed from west to east as follows:

SOLOMONS—1 species
anensis

SANTA CRUZ—1 species
lapeyrousei

NEW HEBRIDES—14 forms

alatus	*maculicollis*
ambrymensis	*marginatus*
aobae	*risbeci*
caudatus	*rusticus*
caudatus erromangoi	*santicolus*
convexus	*tannae*
divaricatus	*tannae erromangoana*

FIJI—23 forms

acuticauda	*matukuanus*
bryani	*moalensis*
cervinus	*obtusatus*
durvillei	*painei*
evansi	*prasinus*
expansus	*protensus*
forcipatus	*simmondsi*
granatus	*smaragdus*
greenwoodi	*subangulatus*
griseus	*subtritus*
griseus taveuni	*subvittatus*
leveri	

TONGA—1 species

cinctus

NIUE—1 species

niuei

SAMOA—3 forms

bicolor	*samoensis setiventris*
samoensis	

Elytrurus niuei Zimmerman, new species
Figs. 2–4

COLOR: derm mostly reddish brown, venter mostly darker to nearly black; vestiture mostly creamy white, but with iridescent scales (evidently subject to fading) more abundant on lower surface; scaling denser and more conspicuous on dorsum of female than male, in latter sex the scales form a pale vitta on sides from anterior margin of pronotum to apex of elytra.

STRUCTURE: *Head* with sides, as viewed from above, nearly evenly arcuate from pronotum to apices of eyes, eyes not obviously interrupting this contour; breadth at hind margins of eyes distinctly greater than length from pronotum to anterior edge of an eye (1.75:1.2); length, measured from side, from pronotum to anterior edge of eye equal to distance between fore edge of eye and base of mandible; distance between pronotum and eye equal to length of eye; narrowest frontal interocular distance only a little more than one-half the breadth between hind margins of eyes (10:18); interocular area with a conspicuous median pit which marks the termination of the raised median line or median

FIG. 2. *Elytrurus niuei*, new species, holotype male.

FIG. 3. *Elytrurus niuei*, new species, allotype female.

carina from pit to epistome; crown and front with shallow punctures of medium size interspersed with some minute punctures, most of the larger punctures bearing conspicuous, decumbent setae which are directed toward the midpoint of the crown; scales oval, densest along upper margins of eyes, rather densely continued ventrad to bare median gular sutural line.

Rostrum with greatest preapical breadth subequal to length from fore edge of eye to apex of mandible, longitudinal dorsal contour flattened from just behind interocular pit; sides beneath scrobes continuously squamose with sides of head and with numerous, conspicuous, slanting, erect setae; dorsum impressed on either side of median line which is consequently elevated as a median carina whose development is variable and may be conspicuous or obscure, punctate, squamose and setose as head; epistome rather densely set with mostly small punctures, setose only at sides and without squamae; mentum not setose, with a peduncle about one-fourth to one-third as long as median length of mentum.

Antennae with scape comparatively densely clothed with prostrate, narrow, mostly almost setiform scales, which are more squamiform on dorsal edge, and longer, decumbent setae, apex not quite reaching as far back as anterior one-fourth of side of pronotum, subequal in length to the seven funicular segments combined; funiculus with vestiture less dense and finer than scape, lengths of segments as follows: 1–20, 2–22, 3–12, 4–11, 5–10, 6–10, 7–10; club as long as preceding four funicular segments together, lengths of segments: 1–15, 2–12, 3–15, greatest thickness of segment two 12 (these measurements with micrometer reading 40 units to one millimeter).

Pronotum obviously transverse (28:20), broadest at or just behind middle, anterior margin broadly, shallowly emarginate, posterior margin weakly convex; longitudinal median contour only slightly arcuate; disc punctate-granulate, the punctures on the posterior sides of the granules bearing fine, decurved setae mostly directed obliquely backward toward median line; scales on disc smaller and sparser than on sides, not covering the granules which protrude and are moderately shiny; squamae larger, denser, imbricated on side margins.

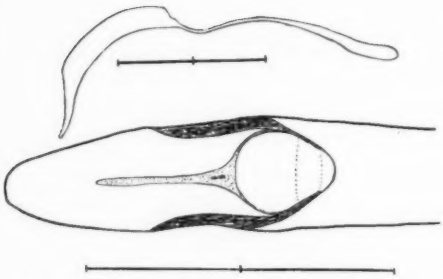

FIG. 4. Aedeagus of *Elytrurus niuei*, new species; upper figure, lateral aspect; lower figure, dorsal aspect of distal part; total length of each scale line is 1.0 mm.

Scutellum broadly protuberant, disc not punctured, not squamose, not setose, rather shiny, very finely alutaceous.

Elytra as illustrated, a little more than three times as long as pronotum, apices only shortly and moderately divaricate; apical processes reduced to low bosses which hardly project behind apex; sides not evenly arcuate into base, but humeri rather straightly oblique; striae not impressed between the rows of moderately sized strial punctures which are separated from each other on disc about the diameter of a puncture or slightly farther, the punctures bearing from their anterior ends decumbent squamiform setae; intervals flat, about two or three times as broad as strial punctures, each bearing a row of small granules from the posterior ends of which arise decurved setae; squamae oval, not imbricated on disc, even on females which have denser scaling, squamae denser and with considerable imbrication on epipleurae.

Sternum squamose and setose; prosternum with posterior median process strongly protuberant; mesosternum with intercoxal process bluntly subtriangular, apex less than one-third as broad as breadth of coxa, densely squamose, exocoxal area conspicuously more densely squamose than episternum, squamae strongly imbricated, scales on episternum separated, those on epimeron smaller and less numerous; metasternum at the shortest distance between mid and hind coxae subequal in length to transverse diameter of a mesocoxa, disc tending to be transversely strigate, squamae there smaller and much sparser than on sides where they are dense but interrupted by rather large setigerous punctures; metepisternum squamose and setose.

Legs squamose and setose, femora more densely squamose than tibiae, but scales not imbricated and not forming patches on outer or dorsal sides; posterior femora extending to beyond base of fifth ventrite; legs similar in the two sexes, anterior tibiae not modified in male; mucrones small on all tibiae; all tibiae with a row of heavy, stiff spines along inner edge in addition to the long stiff setae; corbels of hind tibiae with the bevel considerably reduced and tending toward obsolescence, without a sharp upper line marking the upper (outer) edge of the bevel and without the row of stiff spines or heavy bristles along the upper margin as is found on many species of the genus, although the main (lower, or inner) row of spines separating the bevel from the corbel proper is well developed and normal.

Venter with puncturation moderate, with numerous slanting setae on all ventrites; with scales larger, denser and more conspicuous on sides of segments, those on discs of ventrites one to four narrow and becoming setiform caudad, a wide patch of scales on sides of ventrite four in male, but only a few scales there in female; ventrite five with only a few broad scales at sides at base in male, but apical two-thirds of disc of female clothed with broad and narrow lanceolate scales; with the first ventrite about as long along median line as ventrite two plus three, rather similar in the two sexes; ventrite two as long as three plus four plus about one-half of four again; ventrite five broadly U-shaped, two-thirds as long as wide and more than one-fifth shorter than ventrite one in male, V-shaped, only a little shorter than wide and as long as ventrite one in female, also in the female it is bare in about basal one-third, this bare area has a sublateral groove on either side from base to squamose zone.

LENGTH (including head and rostrum): male, 10–10.5 mm.; female, 12–12.5 mm. Breadth: male, 4.25–4.5; female: 5.25.

Holotype male and allotype female, deposited in the British Museum (Natural History), one male and one female paratype collected by A. C. Gerlach "ex coconut tree" at Fonuakula, Niue Island, in 1953.

This species most closely resembles *Elytrurus cinctus* Boisduval from Tonga, and it appears to have been derived from it. *Elytrurus cinctus* is a larger, mostly black-bodied species with the dorsum conspicuously clothed with green or coppery scales and with a broader, much more conspicuous lateral pale band. The pit between the eyes is a deep hole on *niuei*, but it is shallow or obsolete on *cinctus*. The side of the rostrum beneath the scrobe is densely and conspicuously squamose in *niuei* (and also setose), but in *cinctus* it is only setose. The eyes are somewhat flatter in *niuei* and do not interrupt the lateral outline of the head as much as they do in *cinctus*. The anterior margin of the pronotum is not emarginate in *cinctus* as it is in *niuei*. The fifth ventrite of the female of *cinctus* has the scales reduced to setae or there are a few narrowly lanceolate scales, but on *niuei* there are obviously numerous broader ovoid or broader lanceolate scales.

ELYTRURUS Boisduval

Elytrurus Boisduval, 1835: 400. Schoenherr, 1843: 238. Lacordaire, 1863: 147. Faust, 1897: 230.

Elytrogonus Guérin-Méneville, 1841: 126. Lacordaire, 1863: 148. Faust, 1897: 231. Lona, 1937: 302.

Synonymy by Marshall, 1938: 71. Lona, 1937: 302, catalogue. Lona incorrectly credited *Elytrurus* to Schoenherr and incorrectly listed it as a synonym of *Elytrogonus*. Marshall, 1938: 69, revision and key. Paulian, 1945: 193, discussion and key. Type of the genus: *Elytrurus lapeyrousei* Boisduval, 1835: 400. Cited by Schoenherr, 1843: 239.

The following species have been described in *Elytrurus* or *Elytrogonus* but are synonyms or have been transferred to other genera:

Elytrurus Angulatus Waterhouse is a synonym of *Elytrurus expansus* Waterhouse.

Elytrurus bivittatus Marshall is a synonym of *Elytrurus bicolor* Marshall.

Elytrogonus coquereli Fairmaire is a *Rhyncogonus*.

Elytrurus dentipennis Fairmaire is a synonym of *Elytrurus caudatus* Pascoe.

Elytrogonus griseus Montrouzier is an *Anomalodermus*.

Elytrurus horizontalis Fairmaire is a synonym of *Elytrurus subvittatus* Pascoe.

Elytrogonus otiorhynchoides Fairmaire is a *Rhyncogonus*.

Elytrurus (*?*) *papuanus* Heller is a *Hellerhinus*.

Elytrurus serrulatus Waterhouse is a synonym of *Elytrurus rusticus* Pascoe.

Elytrurus squamatus Rainbow is a synonym of *Trigonops insularis* (Boheman).

Elytrurus vanikorae Heller is a synonym of *Elytrurus lapeyrousei* Boisduval.

CATALOGUE OF THE SPECIES

1. **acuticauda** Fairmaire (1879: 46; 1880: 208); Marshall (1938: 90, fig. 14); Paulian (1945, fig. 55).
   Elytrogonus acuticauda (Fairmaire) Lona (1937: 302).
   Fiji: Taveuni.
2. **alatus** Saunders and Jekel (1855: 290, pl. 15, fig. 1); Lacordaire (1863: 148); Marshall (1938: 90).
   Elytrogonus alatus (Saunders and Jekel) Lona (1937: 302).
   New Hebrides: Futuna.

In *Coleopterorum Catalogus*, the locality is given as Lord Howe Island, but this Futuna should not be confused with the Lord Howe Island between Australia and New Zealand or Ontong Java ("Lord Howe") or Futuna, Horne Islands west of Samoa.

3. **aobae** Paulian (1945: 199, figs. 46, 47).
   New Hebrides: Omba (Oba, Aoba).

4. **ambrymensis** Marshall (1938: 81); Paulian (1945, figs. 43, 66).
   New Hebrides: Ambrim (Ambrym).
5. **anensis** Marshall (1938: 82).
   Solomons: Santa Ana.
6. **bicolor** Marshall (1921: 588; 1931: 260, fig. 3; 1938: 76).
   Elytrogonus bicolor (Marshall) Lona (1937: 302).
   Elytrurus bivittatus Marshall (1921: 588); synonymy by Marshall (1931: 260).
   Samoa: Tutuila, Upolu, Savaii. Type locality cited only as "Samoan Islands."
7. **bryani** Marshall (1938: 84, fig. 7).
   Fiji: Naiau.
8. **caudatus** Pascoe (1870: 471, pl. 18, fig. 5); Fairmaire (1880: 209); Marshall (1938: 89, fig. 13); Paulian (1945, fig. 61).
   Elytrogonus caudatus (Pascoe) Lona (1937: 302).
   Elytrurus dentipennis Fairmaire (1879: 46; 1880: 209); synonymy by Marshall (1938: 89).
   Elytrogonus dentipennis (Fairmaire) Lona (1937: 302).
   New Hebrides: Tana (Tanna).

This species has erroneously been recorded from Fiji by Fairmaire (1879: 46; 1880: 209) and others.

9. **caudatus erromangoi** Paulian (1945: 196, figs. 49, 61, 62).
   New Hebrides: Eromanga (Errormango).

The status of this form requires further study; it may be a species.

10. **cervinus** Marshall (1938: 76, fig. 1).
    Fiji: Ovalau.
11. **cinctus** Boisduval (1835: 401); Boheman (1843: 240); Fairmaire (1849: 511; 1880: 211); Lacordaire (1863: 148); Marshall (1938: 80); Paulian (1945: 197, figs. 39, 58).
    Elytrogonus cinctus (Boisduval) Lona (1937: 302).
    Tonga: Neiafu (Vavau Group), Vavau, Tongatabu.

Specimens have been seen in collections which bear incorrect locality labels. Boisduval originally stated erroneously that it came from Vanikoro (Santa Cruz Islands). In *Coleopterorum Catalogus*, the localities "Neue Hebriden, Vanikor, Tanga" (all in error) are given. Paulian (1945: 197) records it from Fiji in error. Fairmaire (1880: 211) pointed out the errors in locality and gave the true locality as Tonga. Numerous specimens, all from Tonga, have been seen.

12. **convexus** Paulian (1945: 201, fig. 35).
    New Hebrides: Espiritu Santo.
13. **divaricatus** Waterhouse (1877: 10); Fairmaire (1880: 212); Marshall (1938: 82); Paulian (1945, fig. 53).
    Elytrogonus divaricatus (Waterhouse) Lona (1937: 302).
    New Hebrides: Ambrim (Ambrym), Efate (Vati, type locality).
14. **durvillei** Blanchard (1853: 221); Fairmaire (1880: 210); Lacordaire (1863: 148); Marshall (1938: 93); Paulian (1945, figs. 48, 69).
    Elytrogonus Durvillei (Blanchard) Lona (1937: 303).
    Fiji: Vanua Levu.

Erroneously listed in *Coleopterorum Catalogus* from "Labouka" (error for Levuka, Ovalau).

15. **evansi** Marshall (1938: 82, fig. 6).
    Fiji: Taveuni.
16. **expansus** Waterhouse (1877: 8); Fairmaire (1880: 207); Marshall (1938: 90, figs. 15, 16).
    Elytrogonus expansus (Waterhouse) Lona (1937: 303).
    Elytrurus angulatus Waterhouse (1877: 8); synonymy by Fairmaire (1880: 208).
    Fiji: Ovalau (type locality), Viti Levu.

In *Coleopterorum Catalogus*, Ovalau is misspelled Ovalan.

17. **forcipatus** Marshall (1938: 85, fig. 8).
    Fiji: Tuvutha (Lau Group).
18. **granatus** Fairmaire (1879: 46 [misprinted in Marshall as p. 116]; 1880: 210); Marshall (1938: 93); Paulian (1945, figs. 67, 68).

Elytrogonus granatus (Fairmaire) Lona (1937: 303).
Fiji: Taveuni (possible type locality), Viti Levu.

19. **greenwoodi** Marshall (1938: 94, figs. 20, 21).
Fiji: Viti Levu.

20. **griseus** (Guérin-Méneville).
Elytrogonus griseus Guérin-Méneville (1841: 126; type of *Elytrogonus*); Blanchard (1853: 237, pl. 15, figs. 1, 2); Lacordaire (1863: 149); Fairmaire (1881: 293); Lona (1937: 303).
Elytrurus griseus (Guérin-Méneville) Marshall (1938: 78).
Fiji: Matuka, Moala, Ovalau, Taveuni, Totoya, Vanua Levu, Viti Levu, Wakaya. Lau Group: Avea, Kambara, Kanathea, Katafanga, Komo, Lakemba, Mango, Mothe, Naiau, Namuka, Oneata, Thithia, Tuvutha, Vanua Mbalavu, Vanuavatu.

In the original description the type locality was erroneously stated to have been Triton Bay, New Guinea, but the species is Fijian. Marshall misspelled Totoya as Totova, and Oneata as Onesta.

It is interesting that this one species should have become so widespread through the islands, whereas most of the other species have restricted distributions. It is the commonest species of *Elytrurus*, and its habits appear to have contributed to its distribution by the aid of man. It may at times become a minor pest.

21. **griseus taveuni** Marshall (1938: 78, as subspecies of *griseus*).
Fiji: Taveuni.

22. **lapeyrousei** Boisduval (1835: 400); Lacordaire (1863: 148); Marshall (1938: 88); Paulian (1945: 196, fig. 57).
Elytrurus Lapeirousei Boisduval, Boheman, in Schoenherr (1843: 239).
Elytrogonus Lapeyrousei (Boisduval) Lona (1937: 303).
Elytrurus vanikorae Heller (1935: 269); synonymy by Marshall (1938: 88); Paulian (1945: 195, footnote, fig. 38; this species?).
Elytrogonus vanikorae (Heller) Lona (1937: 304).
Santa Cruz Islands: Vanikoro.
Type of the genus.

23. **leveri** Marshall (1938: 92).
Fiji: Vanua Levu.

24. **maculicollis** Heller (1916: 358); Marshall (1938: 82); Paulian (1945: 196, figs. 41, 42, 44, 45, 63).
Elytrogonus maculicollis (Heller) Lona (1937: 303).
New Hebrides: Epi (type locality), Malekula.

25. **marginatus** Saunders and Jekel (1855: 291, pl. 15, fig. 2); Lacordaire (1863: 148); Marshall (1938: 86); Paulian (1945, fig. 54).
Elytrogonus marginatus (Saunders and Jekel) Lona (1937: 303).
New Hebrides: Aneityum (Aneiteum), Eromanga.

In *Coleopterorum Catalogus* it is erroneously listed from "Lord Howe." The exact type locality is unknown.

26. **matukuanus** Marshall (1938: 79).
Fiji: Matuku.

27. **moalensis** Marshall (1938: 87).
Fiji: Moala.

28. **niuei** Zimmerman, new species.
Niue Island.

29. **obtusatus** (Fairmaire).
Elytrogonus obtusatus Fairmaire (1881: 293); Lona (1937: 303).
Elytrurus obtusatus (Fairmaire) Marshall (1938: 78); Paulian (1945: fig. 64).
Fiji: Viti Levu.

30. **painei** Marshall (1938: 80, figs. 4, 5).
Fiji: Mbengga.

31. **prasinus** Marshall (1938:87, figs. 10, 11).
Fiji: Kandavu.

32. **protensus** Marshall (1938: 93, fig. 19).
Fiji: Viti Levu.

33. **risbeci** Marshall (1937: 39; 1938: 80, fig. 3); Risbec (1937: 157, pl. 1, fig. 13);

Paulian (1945: 196, figs. 40, 56).
Elytrogonus Risbeci (Marshall) Lona (1937: 303).
New Hebrides: Efate (Vate).

34. **rusticus** Pascoe (1881: 589); Fairmaire (1881: 292); Marshall (1938: 80); Paulian (1945, fig. 70).
Elytrogonus rusticus (Pascoe) Lona (1937: 303).
Elytrurus serrulatus Waterhouse (1897: 10); Fairmaire (1880: 212); synonymy by Marshall (1938: 80).
Elytrogonus serrulatus (Waterhouse) Lona (1937: 303).
New Hebrides: Aneityum ?, Efate (Vate, Vati), Tana (Tanna).

Erroneously recorded by Fairmaire (1881: 292) from Fiji, and the error repeated in *Coleopterorum Catalogus*. In Marshall (1938: 80) delete the "1877" after Waterhouse.

35. **samoensis** Marshall (1921: 587; 1938: 76).
Elytrogonus samoensis (Marshall) Lona (1937: 303).
Samoa (exact type locality not known).

36. **samoensis setiventris** Marshall (1921: 587, a variety).
Elytrogonus samoensis setiventris (Marshall) Lona (1937: 303).
Samoa: Tutuila.

Marshall did not mention this form in his monograph of the Samoan Curculionidae (1931) or in his revision of *Elytrurus* (1938).

37. **santicolus** Marshall (1938: 77).
New Hebrides: Espiritu-Santo.

38. **simmondsi** Marshall (1938: 90, fig. 17).
Fiji: Viti Levu.

39. **smaragdus** Marshall (1938: 88, fig. 12).
Fiji: Kandavu.

40. **subangulatus** (Fairmaire).
Elytrogonus subangulatus Fairmaire (1883: 34); Lona (1937: 303).
Elytrurus subangulatus (Fairmaire) Marshall (1938: 79).
Fiji: Viti Levu.

Originally recorded in error from Duke of York Island by Fairmaire.

41. **subtritus** Marshall (1938: 92, fig. 18).
Fiji: Ovalau.

42. **subvittatus** Pascoe (1881: 589); Fairmaire (1881: 291); Marshall (1938: 86).
Elytrogonus subvittatus (Pascoe) Lona (1937: 303).
Elytrurus horizontalis Fairmaire (1881: 291); synonymy by Marshall (1938: 86).
Elytrogonus horizontalis (Fairmaire) Lona (1937: 303).
Fiji: Ovalau, Ngau (exact type locality not known, but probably Ovalau).

43. **tannae** Paulian (1945: 197, fig. 51).
New Hebrides: Tana (Tanna).

44. **tannae erromangoana** Paulian (1945: 198, fig. 52).
New Hebrides: Eromanga (Erromango).

The status of this form requires study; it may be a species.

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Taxonomic Considerations of the Lantern Fish *Polyipnus spinosus* Günther and Related Species

YAICHIRO OKADA and KIYOSHI SUZUKI[1]

THE THREE SPECIES treated in this paper (*Polyipnus spinosus* Günther, *P. stereope* Jordan and Starks, and *P. trigentifer* McCulloch) are rather rare lantern fishes belonging to the family Sternoptychidae. *P. spinosus* (Fig. 1) is a deep sea species known to occur off the Philippines, Borneo, in the Gulf of Guinea, off Cape Morgan, Natal coast, in the Andaman Sea, Suruga Bay, and Kumano-Nada, Japan. *P. stereope* has been taken in Sagami Bay, Suruga Bay, and Kumano-Nada, Japan. *P. trigentifer* is known only from the Great Australian Bight. Several ichthyologists have presented opinions on the relationship of these species but their validity has remained in doubt.

In 1887 Günther described *Polyipnus spinosus* from a specimen obtained from the deep sea between the Philippines and Borneo. Subsequently Alcock (1889), Wood-Mason and Alcock (1891), Goode and Bean (1895), Brauer (1906), Weber and de Beaufort (1913), Barnard (1925), Fowler (1936), Parr (1937), Schultz (1938), and Matsubara (1941, 1950) have also described this species. In 1904 Jordan and Starks described *Polyipnus stereope* based on a specimen collected by the U.S. Fish Commission Steamer "Albatross" from Sagami Bay, and remarked that this species differs from *Polyipnus spinosus* Günther in the character of the posttemporal process. In 1914 McCulloch described *Polyipnus trigentifer* as a new species based on many specimens collected from the Great Australian Bight. At the end of his description of *Polyipnus trigentifer* he noted that this species is very near to *Polyipnus spinosus* Günther and *Polyipnus stereope* Jordan and Starks but has more dorsal and anal rays, a greater number of anal photophores, and a much greater development of the posttemporal process.

The amalgamation of these three species into one has been proposed by Schultz and by Matsubara. In 1938, in his review of the fishes of the genera *Polyipnus* and *Argyropelecus* (Family Sternoptychidae), Schultz considered *Polyipnus stereope* Jordan and Starks and *Polyipnus trigentifer* McCulloch to be synonyms of *Polyipnus spinosus* Günther. In 1941, Matsubara described the fishes of the genus *Poly-*

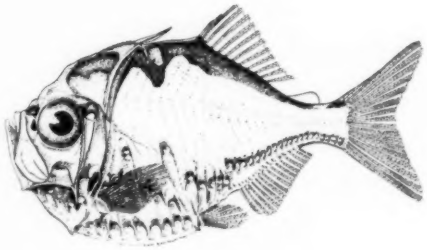

FIG. 1. *Polyipnus spinosus* Günther, natural size. (No. 4810, Kumano-Nada.)

[1] Faculty of Fisheries, Prefectural University of Mie, Tsu-City, Japan. Manuscript received July 5, 1955.

ipnus found in Suruga Bay and concurred in Schultz's opinion concerning *Polyipnus spinosus* Günther. Furthermore, in 1952, in his examination of the fishes of the genus *Polyipnus* taken from Kumano-Nada, Matsubara treated *Polyipnus stereope* Jordan and Starks and *Polyipnus trigentifer* McCulloch as synonyms of *Polyipnus spinosus* Günther.

Among the fishes obtained off Owashi, Mie Prefecture, in November, 1953, and April, 1954, at a depth of about 200 fathoms, were 130 specimens of the genus *Polyipnus*. Upon careful examination of these specimens and a review of the descriptions given by various authors we came to the conclusion that there exist two distinct forms among these specimens and that 98 are referable to *Polyipnus spinosus* Günther and 32 to *Polyipnus stereope* Jordan and Starks. A distinction between the two is obvious in such body proportional characters as depth at origin of dorsal, depth at the end of dorsal, depth of caudal peduncle, and length of posttemporal process in relation to body length, and in such meristic characters as number of gill rakers on the first gill arch and number of pectoral fin rays. These differences are here considered in detail.

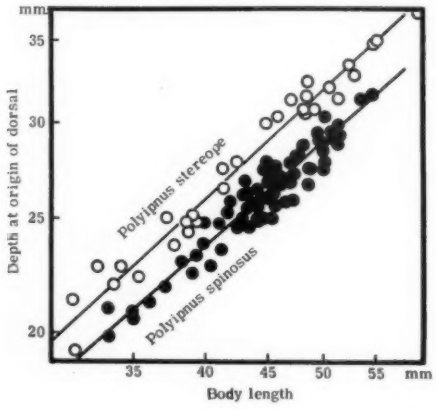

FIG. 2. The allometric lines of depth at origin of dorsal–body length in *Polyipnus spinosus* and *P. stereope*.

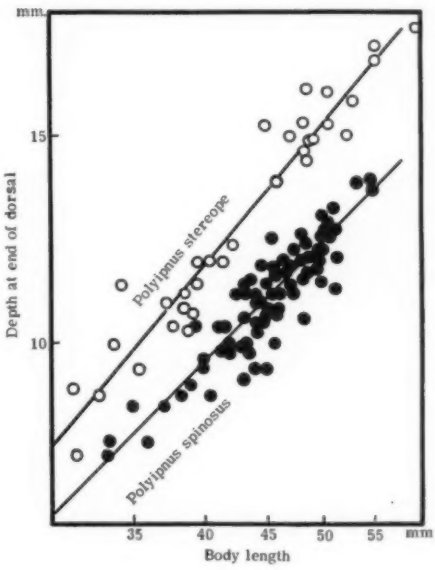

FIG. 3. The allometric lines of depth at end of dorsal–body length in *Polyipnus spinosus* and *P. stereope*.

Body Proportional Characters

Huxley's allometic equation[2] is respectively applied to the four body parts to the body length in order to define the difference of the quantitative morphogenesis of these body parts between *P. spinosus* and *P. stereope*. The growth coefficient and initial growth index in samples of each body part to the body length in two allometric lines are indicated in Table 1.

For the two allometric lines of four body parts to the body length, a test of significancy of "slope differences" and "positional differences" was respectively carried out. The results are:

a. Depth at origin of dorsal–body length relationship (Fig. 2, Table 2). As indicated

[2] The equation is now generally written $y = bx^{\alpha}$, and is termed the single allometric formula. It may be given the form $\log y = \log b + \alpha \log x$ ($y = b + \alpha x$), showing that when the logarithms of two dimensions x and y obeying the law are plotted against one another, the points lie along a straight line.

TABLE 1
GROWTH COEFFICIENT ($\hat{a}$) AND INITIAL GROWTH INDEX ($\hat{b}$) IN SAMPLE OF FOUR BODY PARTS TO THE BODY LENGTH

	Polyipnus spinosus		*Polyipnus stereope*	
	$\hat{a}$	$\hat{b}$	$\hat{a}$	$\hat{b}$
(a) Depth at origin of dorsal	0.89682	−0.06331	0.93898	−0.09277
(b) Depth at end of dorsal	1.05345	−0.70645	1.22516	−0.89722
(c) Depth of caudal peduncle	0.72965	−0.52539	0.95444	−0.77841
(d) Length of posttemporal process	0.54217	0.16408	0.55194	0.08096

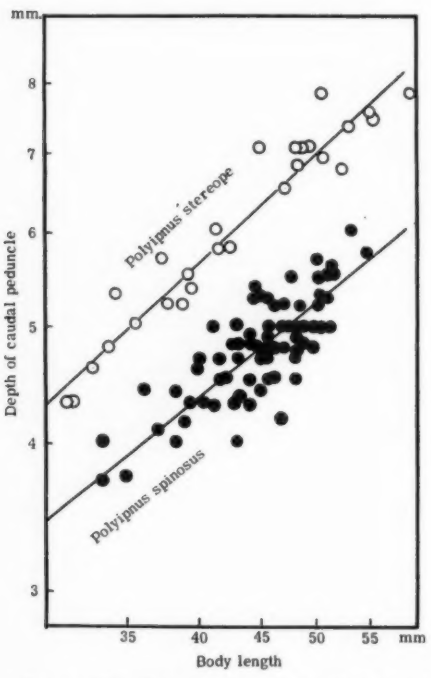

FIG. 4. The allometric lines of depth of caudal peduncle–body length in *Polyipnus spinosus* and *P. stereope*.

in Table 2, there is no significant difference with "slope," but the "positional difference" is obviously significant (level of significance, 1 per cent).

b. Depth at end of dorsal–body length relationship (Fig. 3, Table 3). As indicated in Table 3, the two lines have different "slopes" (level of significance, 5 per cent) and "positions" (level of significance, 1 per cent).

c. Depth of caudal peduncle–body length relationship (Fig. 4, Table 4). As indicated in Table 4, the "slopes" and "positions" representing the two allometry lines are significantly different (level of significance, 1 per cent in each case).

d. Length of posttemporal process–body length relationship (Fig. 5, Table 5). As indicated in Table 5, there is no significant difference with "slope," but the "positional difference" is obviously significant (level of significance, 1 per cent).

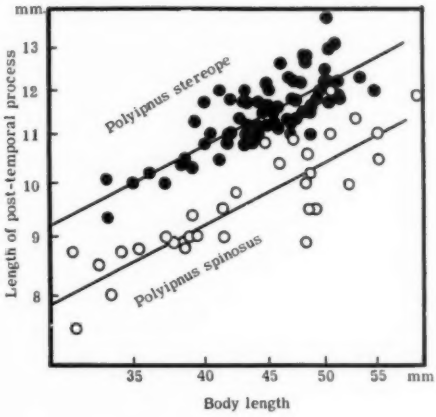

FIG. 5. The allometric lines of length of the posttemporal process–body length in *Polyipnus spinosus* and *P. stereope*.

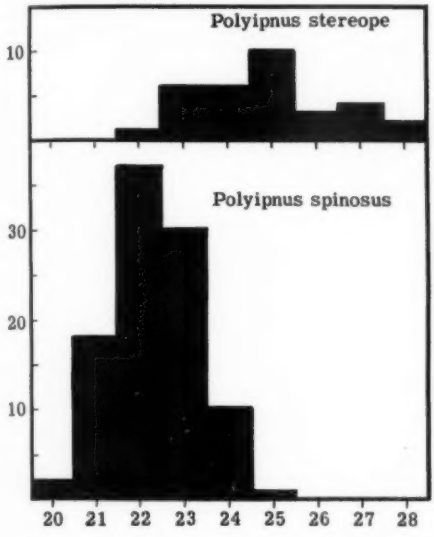

FIG. 6. Frequency of gill rakers on the first gill arch of *Polyipnus spinosus* and *P. stereope*.

The results of these analyses are summarized in Table 6.

Significant "slope differences" in the two allometric lines may be recognized in the depth at end of dorsal to body length and depth of caudal peduncle to body length but not in the depth at origin of dorsal and length of posttemporal process to body length. Furthermore, "positional differences" in the two allometric lines undoubtedly may be expected in these body parts to body length.

Meristic Characters

To indicate the differences of meristic characters between the two species more satisfactorily, we have indicated the frequency distributions of meristic characters by histograms for each species. The two meristic characters used are:

1. Numbers of gill rakers on the first arch (Fig. 6).

In *P. spinosus* the numbers of gill rakers on the first arch are distributed from 20 to 25 and the mode of these frequencies may be recognized at 22. But in *P. stereope* the frequencies are distributed from 22 to 28 and the mode of these frequencies may be recognized at 25.

2. Numbers of pectoral fin rays (Fig. 7).

In *P. spinosus* the numbers of pectoral fin rays are distributed from 12 to 14 and the mode of these frequencies may be recognized at 13. But in *P. stereope* the frequencies are distributed from 13 to 16 and the mode may be recognized at 14.

From these observations we have found that the two species are apparently separable in four body proportional characters and two meristic characters. Therefore we conclude that *Polyipnus stereope* Jordan and Starks should be treated as a distinct species. We are unable to come to a decision as to whether *Polyipnus trigentifer* McCulloch is to be regarded as a synonym of one of these other two species or not, because we were unable to obtain Australian specimens of *Polyipnus trigentifer* McCulloch to compare with the present two species. However *Polyipnus trigentifer* McCulloch seems to differ from both of the present two species in the numbers of anal photophores, that is it has 15–17 whereas the other two species have 12–14.

TABLE 2
"SLOPE AND POSITIONAL DIFFERENCES" BETWEEN TWO ALLOMETRIC LINES OF DEPTH AT ORIGIN OF DORSAL–BODY LENGTH RELATIONSHIP

RESIDUE FORM	SUM OF SQUARES	(d.f.)	(S.S./d.f.)
Separate lines	0.02136	126	0.000170
Slope differences	0.00016	1	0.000160
Parallel lines	0.02125	127	$F_0 = 0.941$
Parallel lines	0.02125	127	0.000169
Positional differences	0.03738	1	0.037380
Single line	0.05890	128	$F_0 = 221.183^{**}$

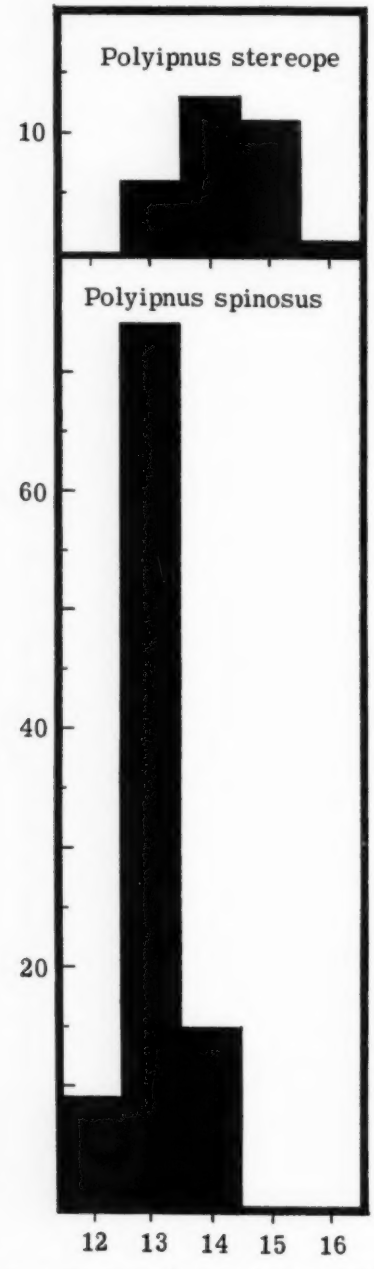

FIG. 7. Frequency of pectoral fin rays in *Polyipnus spinosus* and *P. stereope*.

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TABLE 3
"SLOPE AND POSITIONAL DIFFERENCES" BETWEEN TWO ALLOMETRIC LINES OF DEPTH AT END OF DORSAL–BODY LENGTH RELATIONSHIP

RESIDUE FORM	SUM OF SQUARES	(d.f.)	(S.S./d.f.)
Separate lines	0.06835	126	0.000542
Slope differences	0.00261	1	0.002610
Parallel lines	0.07096	127	$F_0 = 4.817^*$
Parallel lines	0.07096	127	0.000559
Positional differences	0.19794	1	0.197940
Single line	0.26890	128	$F_0 = 354.097^{**}$

TABLE 4
"SLOPE AND POSITIONAL DIFFERENCES" BETWEEN TWO ALLOMETRIC LINES OF DEPTH OF CAUDAL PEDUNCLE–BODY LENGTH RELATIONSHIP

RESIDUE FORM	SUM OF SQUARES	(d.f.)	(S.S./d.f.)
Separate lines	0.06968	126	0.000553
Slope differences	0.00448	1	0.004480
Parallel lines	0.07416	127	$F_0 = 8.101^{**}$
Parallel lines	0.07416	127	0.000584
Positional differences	0.32115	1	0.321150
Single line	0.39531	128	$F_0 = 549.932^{**}$

TABLE 5
"SLOPE AND POSITIONAL DIFFERENCES" BETWEEN TWO ALLOMETRIC LINES OF LENGTH OF POSTTEMPORAL PROCESS–BODY LENGTH RELATIONSHIP

RESIDUE FORM	SUM OF SQUARES	(d.f.)	(S.S./d.f.)
Separate lines	0.04707	126	0.000374
Slope differences	0.00000	1	0.000000
Parallel lines	0.04707	127	$F_0 = 0.000$
Parallel lines	0.04707	127	0.000371
Positional differences	0.10539	1	0.105390
Single line	0.15246	128	$F_0 = 284.070^{**}$

TABLE 6
SUMMARY OF "SLOPE AND POSITIONAL DIFFERENCES" BETWEEN TWO ALLOMETRIC LINES OF FOUR BODY PARTS TO BODY LENGTH

BODY PART	SLOPE DIFFERENCES	POSITIONAL DIFFERENCES
(a) Depth at origin of dorsal	–	**
(b) Depth at end of dorsal	*	**
(c) Depth of caudal peduncle	**	**
(d) Length of posttemporal process	–	**

**, significant (level of significance 1%)
*, significant (level of significance 5%)
–, insignificant

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The Probable Method of Fertilization in Terrestrial Hermit Crabs Based on a Comparative Study of Spermatophores[1]

DONALD C. MATTHEWS[2]

ALTHOUGH the physiological and mechanical phenomena of the vasa deferentia resulting in the elaboration of the spermatophores of marine hermit crabs (Pagurida) have been investigated (Mouchet, 1931; Matthews, 1953), these phenomena in terrestrial hermit crabs (*Coenobita* and *Birgus*) have been neglected. Spermatophores of marine hermits are made with precision; the so-called immutable form of their acuminate capsules is often distinctive of the species. These capsules, "elevated" on slender stalks, are admirably adapted for aquatic dissemination of the spermatozoa. Because marine hermit crabs are regarded as the progenitors of terrestrial hermit crabs, the present study was undertaken to reveal whether the form of the aquatic spermatophore has become modified in the change to a terrestrial environment, and if so, to consider, in lieu of actual observation, whether these modifications are of sufficient magnitude to make tenable the common assumption that in terrestrial hermits fertilization occurs on land.

METHODS AND TECHNIQUES

The method employed was to study the phenomena of spermatophore elaboration in (1) a truly aquatic hermit crab, (2) a "transitional" terrestrial hermit with gastropod shell, and (3) a terrestrial hermit, no longer protected by a gastropod shell. For the typical aquatic hermit, *Dardanus punctulatus* (*vide* Edmondson, 1946: 265) was selected. These were taken at Oahu, Territory of Hawaii, between June, 1953, and July, 1954. *Coenobita rugosus*, the selected "transitional" hermit, and *Birgus latro*, the selected terrestrial hermit, were taken at Eniwetok Atoll (Marshall Islands) between September 1, 1954, and September 15, 1954.

The abundant *C. rugosus* were easily collected but the scarce *B. latro* had to be dug from their burrows. These hermits were killed and dissected at the Marine Laboratory at Eniwetok. There, the male reproductive systems, for purposes of routine histological examination, were placed in Bouin's fixative, cleared in toluene, embedded in Tissuemat (54°–56° C.), sectioned at 10 microns, stained with standard alum-haematoxylin and counterstained with eosin (0.5 per cent solution in 90 per cent alcohol to which 04. cc. of 0.1 N HCl was added). Some testis sections of both aquatic and terrestrial hermits were stained with Heidenhain's iron-haematoxylin without a counterstain, while others were stained with safranin (Grubler's "Safranin O") and counterstained with light green. Because the large, proximal portions of the vasa deferentia of both aquatic and terrestrial hermits became extremely brittle after fixation, and were sectioned only with difficulty, sim-

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ilar unfixed portions were immersed for 10–30 minutes in an aqueous solution of toluidin blue (1–10,000), teased open in sea water, and their vitally stained contents studied.

OBSERVATIONS

Macroscopic Observation of Abdomens

When removed from the protective gastropod shell, the soft, vulnerable abdomen of *D. punctulatus* is seen to be twisted in accordance with the clockwise helical shell. Although five tergal plates are clearly discernable, they are weakly sclerotized. Pleopods are present only on the left side. The uropods are highly modified and serve primarily as hold-fasts.

Removal of the protective gastropod shell from *C. rugosus* discloses an abdomen which approximates that of *D. punctulatus*. Again the soft abdomen is twisted in compliance with the spiral shell and although five tergal plates are present they are poorly sclerotized. As in aquatic hermits, the pleopods are present only on the left side. Again the uropods are modified for attachment.

The unprotected abdomen of *B. latro* (*vide* Harms, 1932: figs. 1, 2, 3, 4) is straight, stubby, and its broad tergal plates are more heavily sclerotized than either those of *D. punctulatus* or *C. rugosus*. Pleopods are again restricted to the left side. The uropods are modified and reduced but obviously serve no longer as hold-fasts.

Macroscopic Observations of Dissected Abdomens

Typical of the dissected abdomens of aquatic hermits is (Matthews, *op. cit.*, fig. 2–b, p. 257) that of *D. punctulatus* in which a large, paired, hepatopancreas almost fills the entire abdominal cavity. The hepatopancreas, because of connecting mesenteries, carries the testes and vasa deferentia as it follows the turns of the abdomen and is largely responsible for the asymmetrical visceral arrangement. As in other aquatic hermits which inhabit right-handed shells, the right testis and right vas deferens are crowded and somewhat reduced.

The dissected abdomen of *C. rugosus* is almost identical with that of *D. punctulatus*. Again the large hepatopancreas almost fills the abdomen and carries with it the crowded testes and vasa deferentia and again this results in the reduction of the right testis and right vas deferens.

The dissected abdomen of *B. latro* reveals a large hepatopancreas joined to the other viscera by mesenteries. The testes and vasa deferentia are neatly fitted between the right and left portions of the hepatopancreas. Slight differences in size of testis and vas deferens are observed, but the smaller occurs on the right or left side indiscriminately.

The living vasa deferentia of *D. punctulatus*, *C. rugosus*, and *B. latro* exhibit spasmodic, muscular contractions (*vide* Matthews, 1953: 258). However, the opacity of the vasa deferentia prevents the actual observation of the effects of these contractions on the pliable sperm mass. But, as will be shown subsequently, these contractions serve both to move the sperm mass along and to mold it in compliance with gradual changes in the conformation of the vasa deferentia.

Microscopic Examination of Sectioned Testes

The sectioned testis of *D. punctulatus* is a highly coiled, continuous, thin-walled tube into which numerous sacculi open (*vide* Matthews, 1953: 258, fig. 3). The sacculi in cross section are observed in all stages of maturity. The immature sacculus is filled with large primary spermatocytes; others, more mature, are filled with spermatids in all stages of metamorphosis. These are expelled from the sacculus into a minute collecting tubule of the testis by the proliferation of new primary spermatocytes from the germinal epithelium of each sacculus. In other words, the old metamorphosing spermatids are crowded or pushed out of the sacculus by the development of new primary spermatocytes. The

study of many sacculi reveals this to be a rhythmical process. This process produces a continuous sperm mass. This undifferentiated sperm mass enters the small, proximal vas deferens (*vide* Matthews, 1953: 259, fig. 6).

Fundamentally, the sectioned testis of *C. rugosus* resembles that of *D. punctulatus*. The sacculi open into a minute, highly coiled collecting tubule. Sacculi are seen in all stages of maturity. Except for slight differences of detail, the process of filling the sacculi with primary spermatocytes and the expulsion of metamorphosing spermatids is identical with that of *D. punctulatus*. Again the combined, rhythmical, saccular activity provides a continuous, undifferentiated sperm mass which enters the proximal portion of the vas deferens.

The sectioned testis of *B. latro* resembles those of *D. punctulatus* and *C. rugosus*. Sacculi in all stages of maturity are observed and again their rhythmical activity fills the minute collecting tubule with metamorphosing spermatids. The differences observed are primarily of size, the sacculi of *D. punctulatus* and *C. rugosus* being generally smaller than those of *B. latro*. Also observed were slight differences in the number and arrangement of sustentacular cells (*vide* Matthews, 1954: 116, fig. 2b). Although these were present in all sacculi whose spermatids were metamorphosing, their fate still remains obscure.

Microscopic Examination of Sectioned Vasa Deferentia

Cross sections through the proximal portion of the vas deferens of *D. punctulatus* reveal a minute cylindrical tube with a thin wall of contractile tissue and cuboidal epithelium, the almost circular lumen of which is completely occupied by a discoidal portion of the continuous, rod-shaped sperm mass (*vide* Matthews, 1953: 259, fig. 6). Except for slight differences in size, comparable portions of the proximal vasa deferentia of *C. rugosus* and *B. latro* appear identical with those of *D. punctulatus*.

In *D. punctulatus*, as the vas deferens gradually increases in diameter the once circular lumen becomes ellipsoidal (*vide* Matthews, 1953: 260, fig. 7). This change in shape of the lumen is the result of the bounding epithelial cells which have become columnar except at the more pointed extremities of the lumen where cuboidal epithelium still persists. An acidophylic secretion from these cuboidal cells lines the lumen but later surrounds and adheres to the sperm mass to form the thin, sperm mass sheath (*vide* Matthews, 1953: 261, fig. 9). In compliance with the change in shape of the lumen, the sheathed sperm mass becomes ellipsoidal. In *C. rugosus* and *B. latro* cross sections through comparable regions of the vas deferens also reveal ellipsoidal lumina and sheathed sperm masses.

In *D. punctulatus*, cross sections of the vas deferens reveal that the ellipsoidal lumen gradually becomes pear-shaped and that the sheathed sperm mass becomes folded into arches (*vide* Matthews, 1953: 262, fig. 10). A new secretion arises from the epithelial cells at the more pointed end of the lumen; this secretion fills the spaces between the closing arches and forms the "upright" stalks (*vide* Matthews, 1953: 262–263, figs. 11, 12, 13). As this secretion accumulates, the stalks lengthen and the ampullae of sperm are carried "aloft."

In *C. rugosus* and *B. latro* a similar change from an ellipsoidal to a pear-shaped lumen is observed and, accompanying this change, the contained, sheathed, sperm mass is folded into arches. In like manner a secretion, arising from epithelial cells of the pointed end of the lumen, fills the spaces between the closing arches and forms the "upright" stalks. Again, as this secretion accumulates, the stalks lengthen and "elevate" the closing arches to form the ampullae of sperm.

In *D. punctulatus*, *C. rugosus*, and *B. latro* (Fig. 1*a–c*) still another secretion is given off by the epithelial cells (*ep.*) bordering the lumen which surrounds the "upright" stalks (*st.*) and ampullae (*am.*) and forms the veil

(*v.*). In *D. punctulatus* the groove of the lumen is deep and results in the formation of tall, thin spermatophores (Fig. 1*a*). In *C. rugosus* (Fig. 1*b*) and *B. latro* (Fig. 1*c*), the groove is shallow and results in the formation of short, broad spermatophores.

DISCUSSION

The spermatophores of *D. punctulatus*, *C. rugosus*, and *B. latro* are formed with great precision. The spermatophores of any one *D. punctulatus* are similar to those of any other of its species. In like manner, the spermatophores of *C. rugosus* and *B. latro* do not vary within the species. However, only in this restricted sense is it permissible to refer to the spermatophores of any one species as being immutable. Because immutable precludes change, its use in connection with spermatophores is untenable. What is probably meant by the use of this term is that, for any one species at the time of observation, spermatophores appear identical. Surely, the complicated mechanical and physiological phenomena associated with spermatophoric development have evolved throughout the ages and these changes have been accompanied by changes in spermatophores.

Although in *D. punctulatus* the actual process of copulation has not been observed, there is little doubt that it occurs in water. This species does not frequent the shallow reef waters and, so far as is known, never comes ashore even at night. Specimens taken in fishermen's nets frequently show spermatophores attached to both body and gastropod shell. This same attachment of spermatophores is also observed in this species at the Honolulu Aquarium where, prior to spermatophoric deposition, males are frequently seen dragging females about. However, since copulation probably takes place at night, it has not been possible to observe the process in these captive specimens. Moreover, as these specimens are afforded no opportunity to leave the tanks, copulation and the subsequent process of fertilization must occur in water. Therefore, the possibility of terrestrial copulation and fertilization in free living specimens remains but seems rather unlikely.

The spermatophores of *C. rugosus* (Fig. 2*b*) resemble closely the spermatophores of *D. punctulatus* (Fig. 2*a*). There are obvious differences in size of ampullae, upright stalks, veil, etc., but the fundamental plan is the same. This fact, coupled with similarities of spermatophoric development, strongly suggests that for this species the rate and extent of adaptive changes in the reproductive system did not parallel the rate and extent of other terrestrial adaptations. The similarity of these spermatophores with those of *D. punctulatus* should not be interpreted as due to the immutability of *C. rugosus* spermatophores, but rather, that at the particular time of observation, the spermatophores of *C. rugosus* had not "progressed" beyond the aquatic spermatophore level attained by *D. punctulatus*.

Again, copulation and the subsequent process of fertilization in *C. rugosus* have not, to the author's knowledge, been recorded. Even though *C. rugosus* in certain of its organ systems is admirably adapted for a terrestrial habitat, caution should be exercised in assuming that all organ systems are equally so adapted. The literature is replete with reference to the female's dependence on the sea. Harms (1932: 260 [translated]) states:

> The East Indian "Coenobites" seem to spawn all year long, but they seem to reach a climax in the months of January to March. During those months I observed how flocks of *Coenobita cavipes* and [C.] *clupeatus* wandered during the night toward the coast of Perbaoengan (East coast of Sumatra) in order to deposit their zoëa into the water. At the end of May till the beginning of July I observed how the beach swarmed with "Coenobites" in all phases of metamorphosis. . . . On the the island of Siberoet I saw the same thing between May 31 to June 5, 1929, but here *Coenobita rugosus* were involved. The young "Coenobites" emerge from the water with tiny snail-shells, and live at first amphibiously.

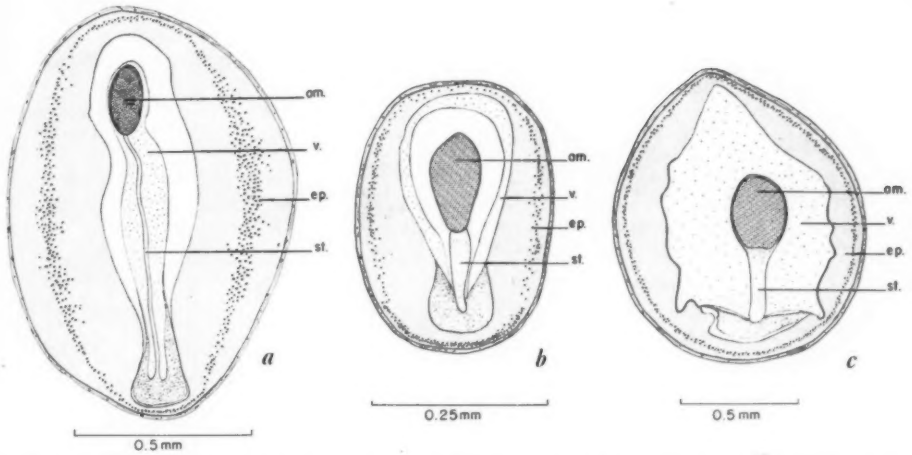

FIG. 1. Diagrammatic cross section of the vas deferens of: *a*, *Dardanus punctulatus; b*, *Coenobita rugosus; c*, *Birgus latro* showing: *am.*, ampulla; *v.*, veil; *ep.*, veil-producing epithelium; *st.*, stalk.

Again in reference to "Coenobites" dependence on the sea, Dr. Yoshio Kondo, terrestrial malacologist of the Bernice P. Bishop Museum, informs me (*in litt.*) that on Saipan swarms of these land crabs make monthly, full-moon migrations to the sea. At this time they are gathered by the bushels for food and, so far as is known, both males and females are taken. The possibility therefore exists that these nocturnal migrations may serve purposes other than the moistening of the gills or the deposition of zoëa.

At Eniwetok I observed both male and female *C. rugosus* on the beach at night although I did not observe any in the water or in the act of copulation. Because females are observed with spermatophores both on their bodies and on their gastropod shells, and because the tubelike extensions on the coxopodite of the fifth pereiopods are too large to serve as penes, it appears quite unlikely that an internal deposition of spermatophores takes place. Both the origin and the aquatic form of *C. rugosus* spermatophores suggest that copulation and fertilization occur in water.

The spermatophores of *B. latro* (Fig. 2*c*) resemble closely the spermatophores of *D. punctulatus* (Fig. 2*a*) and *C. rugosus* (Fig. 2*b*). There are obvious differences in size of ampullae, upright stalks, veils, etc., but again, the fundamental plan is the paguridan aquatic spermatophore. As in *C. rugosus*, this fact, coupled with the similarity of their spermatophoric development, strongly suggests that in *B. latro* also the rate and extent of reproductive adaptations did not parallel the rate and extent of other adaptations. Again, this is not an example of the immutability of spermatophores but rather, at the time of observation, the spermatophores of *B. latro* had not "progressed" beyond the level of the aquatic spermatophore attained by *D. punctulatus*.

Harms (*op. cit.*: 262 [translated]) in reporting on the reproductive activity in *B. latro* says:

> The process of copulation is at this time still unknown. The males do not have special organs for copulation. Yet copulation must take place, and seems to do so on land, since females are found at great distance from the coast. The sperms are probably transmitted by means of spermatophores. In response to excitation I got the male to emit masses of sperm [spermatophores]. These hardened subsequently. . . .

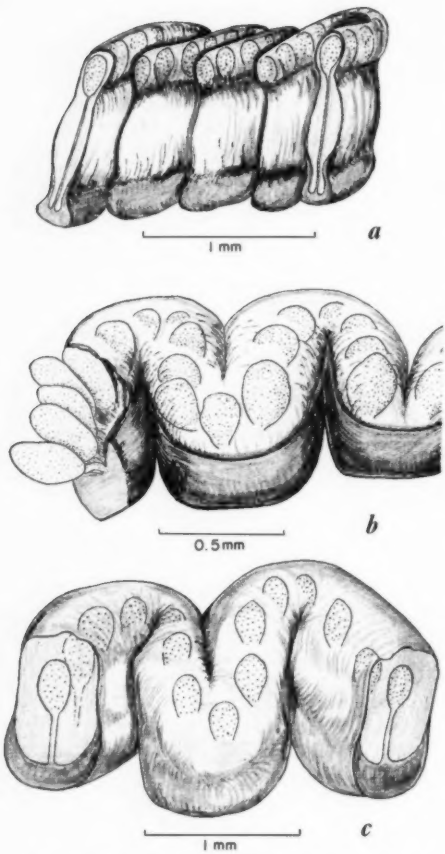

FIG. 2. Portion of vitally stained spermatophore of: *a, Dardanus punctulatus; b, Coenobita rugosus; c, Birgus latro.*

The possibility exists that these gummed up masses of sperm are transferred to the female . . . the development inside the egg goes as far as the zoëa, which has been described by Borradaile [1900]. . . . Birgus has a typical paguride zoëa, which resembles on the whole the zoëas of *Spiropagurus* and of *Eupagurus*. . . . The peculiarity of the zoëas of Birgus lies in a certain simplification of its over-all organization, illustrated especially by the absence of otherwise typical bristles and teeth. Perhaps it can be assumed with certain confidence that further development up to the metamorphosis takes place exactly as with the rest of the pagurids, especially the "Coenobites."

Harms (1937: 14) further states that the eggs are fertilized at the place of deposit and become attached immediately. He does not say however, how or where this process takes place.

According to the observations of Andrews (1900) on Christmas Island, *B. latro*, too, like the "Coenobites" wanders in great flocks to the sea in the months of January to March. Presumably both males and females take part in these migrations and the possibility exists that in this case, as with *C. rugosus*, the purpose might be for copulation as well as the deposition of zoëa.

At Bikini in July 1947 Dr. Robert Hiatt observed numerous zoëa in the water in which a berried female had been contained overnight. He also observed berried females with their abdomens immersed in intertidal pools liberating zoëa.

Because this part of the reproductive cycle of *B. latro* requires an aquatic environment it appears likely that the liberation of sperm from the spermatophore and fertilization are aquatic. This would not obviate the possibility of a terrestrial attachment of the spermatophore. However, the similarity in the development of spermatophores in the "terrestrial" *C. rugosus* and *B. latro* and in the truly aquatic *D. punctulatus*, seems to argue for the assumption that copulation and the subsequent process of fertilization are also aquatic in these terrestrial species. Surely, this assumption is more valid than the assumption that for these species fertilization takes place on land, "since females are found at great distance from the coast." Without attempting to explain what has brought about modifications for a terrestrial existence, modifications of the reproductive system are not as urgent as, for example, those of the respiratory system which must be used continuously once emergence has occurred. Reproduction, although obviously important to maintain the species, is not a continuous process, therefore, not of primary urgency for the survival of the individual. When necessary, the crabs can return

to their old habitat, water, as do the Amphibians.

In lieu of actual observation to the contrary the modifications of the spermatophores of *C. rugosus* and *B. latro* are not of sufficient magnitude to make tenable the common assumption that terrestrial hermit crabs are fertilized on land. Stationed at a likely spot, a patient observer, equipped with an infra-red light, may provide the ultimate solution to this problem by direct observation of copulation and fertilization in terrestrial hermit crabs.

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Two New Fleas (Siphonaptera: Rhadinopsyllinae) from Japan

KÔHEI SAKAGUTI and E. W. JAMESON, JR.[1]

RECENT COLLECTIONS have added two unnamed fleas to the fauna of Japan. Both species are in the subfamily Rhadinopsyllinae; one belongs to the genus *Rhadinopsylla* Jordan and Rothschild and the other is a species of the closely allied genus *Stenischia* Jordan. Attention is called to the recent discussion by Morland and Prince (1954: 1037) on the status of *Rhadinopsylla* and several of its subgenera; they place *Rectofrontia* Wagner as a subgenus of *Rhadinopsylla*, a combination we shall continue to use. Previously Hopkins (1952: 365) placed *Rangulopsylla* Darskaya as a synonym of *Rectofrontia*.

Heretofore *Rhadinopsylla* (*Rectofrontia*) *attenuata* Jameson and Sakaguti has been the only species of Rhadinopsyllinae known from Japan. The two species described in this paper bring this number to three. A fourth species, *Rhadinopsylla* (*Rectofrontia*) *fraterna* ssp., was taken by the senior author from the mouse, *Apodemus geisha*, at Kamikochi in Nagano-Ken (1,500 meters, elevation) 3 December 1952. Several species of *Rhadinopsylla* which are known from the adjacent Asiatic mainland are unknown in Japan. More of these interesting fleas may be found if collectors examine the nests of small mammals.

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Rhadinopsylla* (*Rectofrontia*) *japonica n. sp.
Fig. 1

MALE: Head (Fig. 1*a*) with an acute frontal tubercle and five genal teeth; the uppermost genal tooth is two times as wide as the adjacent tooth and overlaps it at its base. There are two rows of preantennal and three rows of postantennal (occipital) setae. A clear ocular area at the base of the uppermost genal spine. Labial palpus five-segmented, not quite reaching the tip of the fore-coxa.

Pronotum (Fig. 1*a*) with six or seven spines per side. Mesonotum (Fig. 1*b*) with three rows of setae as shown, and with two pseudosetae per side, under the collar. Metanotum with two rows of setae.

Coxa III with a mesal patch of setae. Fifth tarsal segment of each leg with four pairs of lateral plantar bristles.

Each abdominal tergite with a row of alternating long and short setae; abdominal terga I–V each with a small anterior row, and with two to four marginal teeth, placed dorsally. Abdominal sternites each with two or three long setae ventrally.

Fixed process of clasper (Fig. 1*c*) entire, with one long seta laterally near the dorsal margin, and several (six to eight) small setae on the dorsal margin. Moveable finger not extending to the dorsal margin of the clasper. Sternite VIII rudimentary. Sternite IX (Fig.

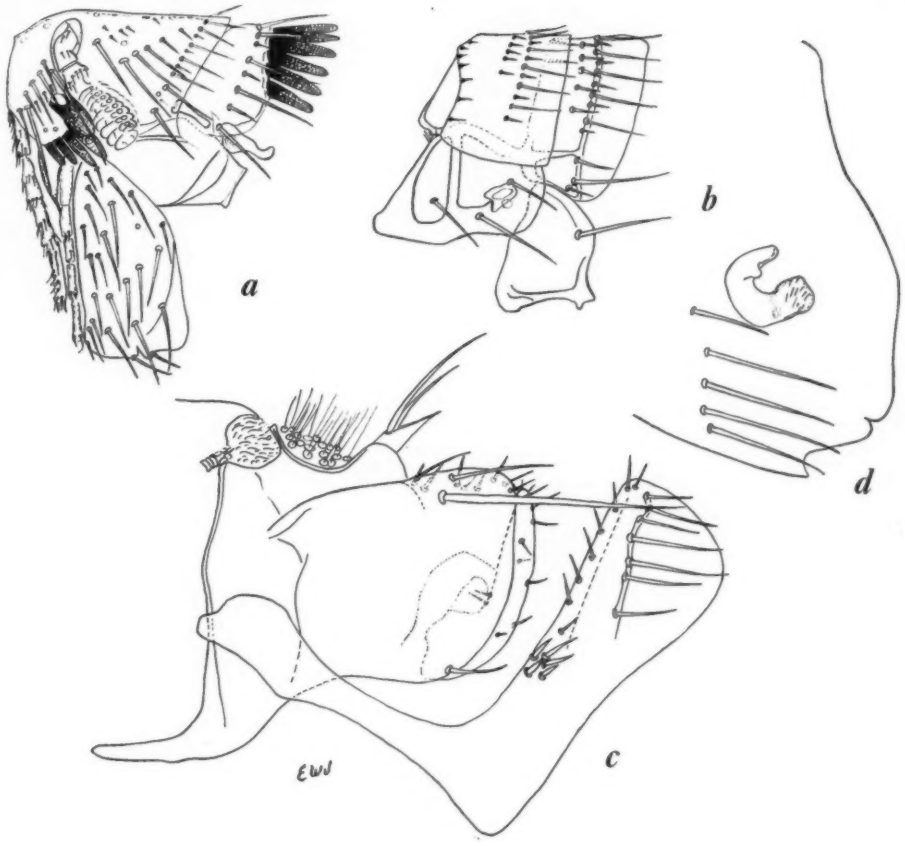

FIG. 1. *Rhadinopsylla* (*Rectofrontia*) *japonica*, new species: *a*, head and prothorax of male; *b*, meso- and metathorax of male; *c*, sternite IX, movable finger, and fixed process of clasper; *d*, sternite VII and seminal receptacle of female.

1*c*) expanded distally; characteristic and unique is the cluster of five or six thick, short setae near the base of the distal arm.

FEMALE: In general similar to male. Chaetotaxy of head as in male. Two antepygidial bristles per side. Sternite VII (Fig. 1*d*) with a sharp incision and a shallow sinus on the ventral margin. Body of seminal receptacle slightly enlarged caudally, the neck gradually narrower than the body; neck with a caudal projection.

TYPES: Holotype male and allotype female from the flying squirrel, *Petaurista leucogenys oreas* Thomas, Mt. Kurama, Kyoto-Fu, Honshu, Japan; 2 Nov. 1952; coll. Kôhei Sakaguti and deposited in the collection of Kôhei Sakaguti. Paratypes with same data as types, 2 Nov. 1952 and from the same host; Kibune, Kyoto-Fu, Honshu, Japan; 10 Jan. 1954; coll. Kosaburo Torii. Paratypes deposited at the British Museum (at Tring) and in the collections of the authors.

REMARKS: This new species resembles *R. pentacanthus* (Rothschild), but the uppermost genal tooth is even more enlarged. The first occipital row of setae is markedly reduced in this new species, and it is unique in the thick setae near the base of sternite IX.

The genus *Stenischia* has been known heretofore only from one female from Szechuan, China. In a recent letter, Mr. Smit of the British Museum wrote that this flea (*Stenischia mirabilis* Jordan) has not since been collected. This second collection of *Stenischia* is from Mt. Fuji, and also consists of but a single female. The Mt. Fuji specimen differs in several respects from *S. mirabilis* and represents an additional species of this genus.

Stenischia fujisania n. sp.
Fig. 2

FEMALE: Head (Fig. 2*a*) with five genal teeth; the uppermost quite small, and overlapping the adjacent genal tooth at its base. The remaining four genal teeth twice as wide and twice as long as the uppermost tooth. Chaetotaxy as illustrated. Labial palpus five-segmented, extending to the apex of the fore-coxa. A narrow, transparent ocular area.

Pronotum (Fig. 2*a*) with seven pigmented teeth per side. Mesonotum (Fig. 2*b*) with a row of four moderately long setae near the caudal margin, and with two pseudosetae under the collar. Metanotum with a strongly

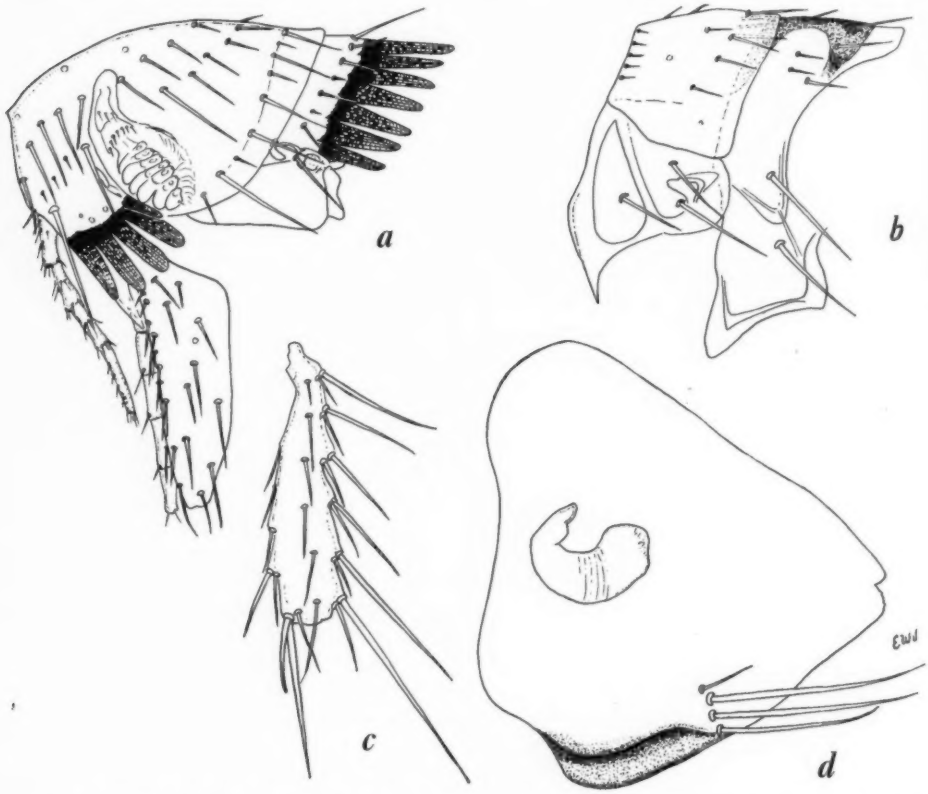

FIG. 2. *Stenischia fujisania*, new species: *a*, head and prothorax of female; *b*, meso- and metathorax of female; *c*, hind tibia of female; *d*, sternite VII and seminal receptacle of female.

sclerotized area dorsally; with two rows of setae on the dorsal half, and a long seta near the ventral margin. Episternum of metathorax fused with metepimerum.

Coxa III with a mesal patch of about thirty fine setae. Setae of hind tibia long (Fig. 2*c*), the long seta at the apex as long as the first tarsal segment. Fifth tarsal segments of the first and second legs each with four lateral plantar bristles; this segment of the third legs is missing in the holotype.

Each abdominal tergite with a row of one to five long setae, separated by smaller setae; on abdominal tergum I is an additional row of small setae anteriorly. Each terga with two or three apical spines, near the dorsal margin. Three antepygidial bristles per side, between which is a caudal extension (from tergum VII) bearing two teeth. Below the antepygidial bristles the margin of tergum VII projects as an acute point. Terga and sterna with dark sclerotized areas (Fig. 2*d*).

Body of seminal receptacle (Fig. 2*d*) evenly rounded, truncate ventrally at the tip. Neck with a caudal swelling. Sternite VII with a small but distinct cleft.

TYPE: Holotype female from *Mustela* sp.; Mt. Fuji, Shizuoka-Ken, Honshu, Japan; 10 July 1954; coll. L. W. Teller. Deposited in the United States National Museum.

REMARKS: *Stenischia fujisania*, n. sp., differs from *S. mirabilis*, the genotype and only other species in the genus, in several features. In *mirabilis* the genal teeth are distinctly separate at their bases but touching in *S. fujisania*. The setae of the tibiae are conspicuous in the new species, and the seminal receptacle is much larger than that of *mirabilis*. In *S. fujisania* there is a distinct cleft or sinus on the margin of sternite VII which is absent in *S. mirabilis*.

It is a pleasure once again to acknowledge the aid we have received from Mr. F. G. A. M. Smit in preparing these descriptions. We are also grateful to Mr. L. W. Teller for allowing us to name the species of *Stenischia* from Mt. Fuji.

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Clasping Mechanism of the Cottid Fish *Oligocottus snyderi* Greeley

ROBERT W. MORRIS[1]

Oligocottus snyderi is a small, tide-pool fish found along part of the Pacific coast of North America. The male of this species has a well-developed penis and fertilization is internal. I studied its breeding and spawning habits under laboratory conditions during a number of years. Copulation was observed on many occasions. No definite patterns of display or courtship activities were apparent and copulation took place in an atmosphere of carefree promiscuity. Such behavior may not be normal, however, for under the conditions of these observations the fish were crowded and subject to the numerous artificialities of laboratory life.

In this species the first two rays of the anal fin of the male are set apart and the first one is much larger and longer than the others of the series (see Fig. 2*a*). This first enlarged ray is prehensile and during copulation it is bent anterolaterally around the female. The lateral curvature of the ray can be directed to either the right or left, permitting the male to seize the female from either side. Copulation takes place away from solid substrate and the embrace may last for as long as 4 or 5 seconds. The strength of the ray's grasp is sufficient to hold the male and female together as they whirl about vigorously (see Fig. 1).

[1] Department of Biology, University of Oregon, Eugene, Oregon. This work was done at Hopkins Marine Station, Pacific Grove, California. Manuscript received October 31, 1955.

ANATOMY

Terminology of the following account is adapted from Starks (1901) and Green and Green (1915).

Figure 2*b* shows the appearance of the male fish after removal of the skin and with the lateral inclinator muscles of the unmodified rays shaded. Each inclinator originates on a myocomma and passes posteriorly across two segments to insert on the side of the head of its ray. Superficially no inclinators are visible on the first two rays.

After removal of the myotomes, the deep muscles associated with the anal fin appear as shown in Figure 3*a*. A section of the peritoneum (bordered by crosshatching) shows how the anal fin mechanism has advanced and reduced the posterior limit of the coelom to a concavity. Discussion of the muscles is deferred until after consideration of the skeleton.

The first three interhemal bones and ossicles are greatly modified as shown in Figure 3*b*. The first interhemal rests on the ossicle at the base of the first ray and arches posteriorly at its dorsal extremity. For its entire length it bears a prominent crest on each side. These crests terminate in broad lateral expansions proximal to the head of the first ray as shown in Figure 4*a*. The second interhemal likewise rests on the first ossicle but also articulates posteriorly with the second. The first ossicle is a doubled bone and in

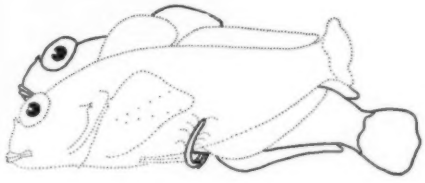

FIG. 1. Approximate positions of the male and female during copulation (male in heavy outline; female stippled outline).

lateral aspect is L shaped. The second ossicle appears to be single and is slightly concave on its dorsal side. The third interhemal articulates with the second and third ossicles. In some specimens the second interhemal has two crests on each side and in others only a single, branched crest as shown in Figure 3*b*. The third interhemal has a single crest on each side.

The left parapophysis of the eleventh vertebra is indicated in stippled outline in Figure 3*b*. The posterodorsal end of the first interhemal is firmly attached to both parapophyses of the eleventh vertebra near the centrum by short, heavy ligaments (see Fig. 4*a*). These parapophyses are in turn firmly anchored to a myocomma and to the transverse septum. Their proximal ends are hooked as shown in Figure 4*b*. I am unable to attach any particular significance to this hook.

The hemirays making up the first ray are held together loosely by connective tissue except at the distal end where they are fused for a length of about 3 or 4 mm. (see Figure 4*a*). This condition permits a degree of independent movement of the hemirays along the long axis. Figure 4*c* shows the first three interhemals and ossicles, and the first two anal rays, the latter with the left hemirays intact. A small hook on the head of the first hemiray turns medially over the dorsal surface of the first ossicle. The heads of the second hemirays are deeply excavate medially and almost completely cover the second ossicle.

Referring again to the muscles shown in Figure 3*a*, the most anterior of the series is seen to originate above the crest of the first interhemal and is inserted on the anterior surfaces of the head of the first ray. This is the erector and is greatly enlarged. The second muscle originates below the crest along the blade of the first interhemal and some of its fibers originate on the second interhemal, in front of the crest(s). Its insertion is over the middle portion of the head of the first hemiray. This muscle appears to be a modified inclinator. The third muscle of the series is a rather narrow one which originates along the middle of the blade of the second interhemal and is inserted on the posterior surfaces of the head of the first ray. It is the depressor. All three of these pairs of muscles are thick

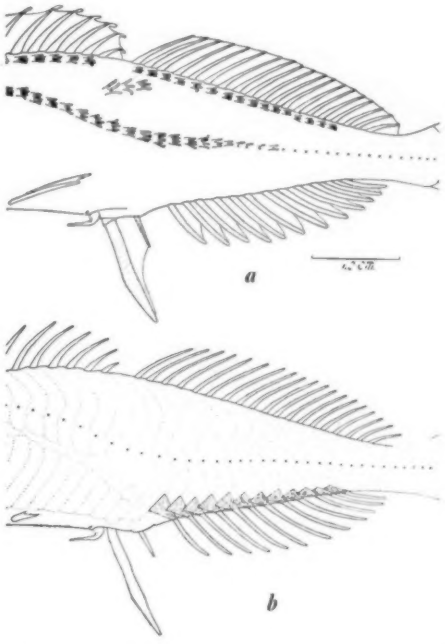

FIG. 2. *a*, Lateral aspect of a portion of the trunk and tail of the male *Oligocottus snyderi*. Protruding from the ventral profile, in left-to-right order are the: Penis, first (enlarged) anal ray, second anal ray, series of 12 unmodified anal rays. *b*, Appearance of superficial musculature after removal of the skin of the trunk and tail. Inclinator muscles of the unmodified anal rays are shaded.

and as a unit they form a subspherical mass.

I could make no distinction between any of the muscles forming the complex inserting on the head of the second ray. The elevator, inclinator, and depressor form a thick, nearly hemispherical mass on each side. This complex originates over the posterior half of the second interhemal blade and the anterior half of the blade of the third.

The erector of the third (first unmodified) ray originates on the posterior surfaces of the third interhemal and inserts on the anterior surfaces of the head of the ray. Its depressor originates on the anterior faces of the fourth interhemal and inserts on the posterior surfaces of the head. As shown in Figure 3*a* the erectors and depressors diminish in size posteriorly and on the last ray I could find only a very small erector and no depressor.

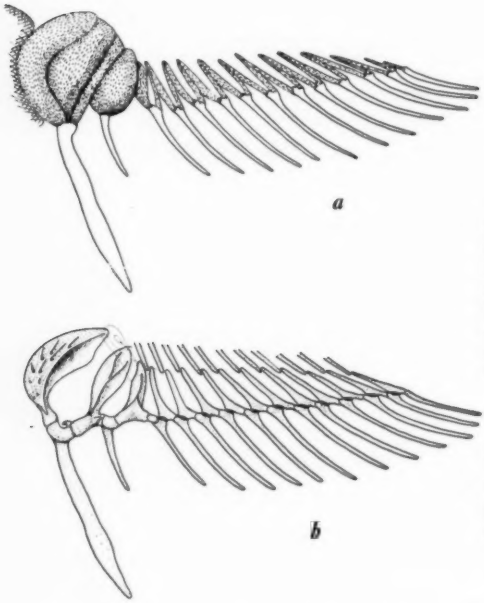

FIG. 3. *a*, Deep musculature of the anal fin. The posterior profile of the body cavity is crosshatched. In left-to-right order the muscles are: Elevator of the first anal ray, inclinator of the first anal ray, depressor of the first anal ray, muscle complex of the second anal ray, elevator of the third anal ray, depressor of the third anal ray, elevators and depressors serially repeated. *b*, Skeleton of the anal fin (with left hemirays removed). Position of left parapophysis of the eleventh vertebra is shown in stippled outline. Ends of the hemal spines of vertebrae 12 to 22, inclusive, are also shown.

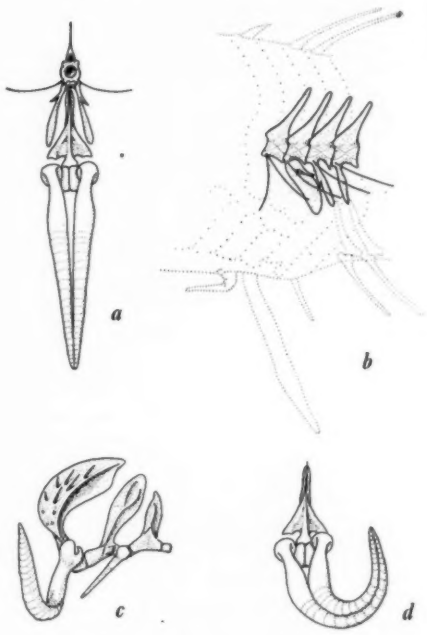

FIG. 4. *a*, Anteroventral aspect of the skeleton of the first anal ray (clasper) and the eleventh vertebra. Note the ligaments connecting the parapophyses of the vertebra with the first interhemal. *b*, Lateral aspect of vertebrae 10 to 13, inclusive. *c*, Lateral aspect of the first three interhemals and ossicles and the first two anal rays with the first ray in a partially flexed position. *d*, Anteroventral aspect of the first interhemal, ossicle, and anal ray with the latter in a flexed position.

FUNCTION

The clasper appears to be flexed in response to either visual or touch stimuli.

Flexion results from the following muscular activities. The first pair of erectors draw the first ray ahead so that it extends from the venter slightly anterior to the perpendicular. The ligaments from the first interhemal to the parapophyses of the eleventh vertebra help

hold the interhemal in position against this action.

The first inclinator of one side (the left for purposes of this description) contracts, drawing the blades of the first and second interhemals closer together. This action retracts the left hemiray, shortening the left side and causing the ray to bend in that direction. The medially directed hook on the head of the right hemiray engages over the first ossicle and prevents that side from being disarticulated.

During flexion, the depressors of the first ray are at rest.

The muscle complex on both right and left sides of the second ray appears to function as a single unit. During flexion of the first ray, this complex contracts, drawing the blades of the second and third interhemals together, thus stabilizing the second interhemal by opposing the action of the first inclinator.

The erector of the third (first unmodified) ray originates on the posterior surfaces of the blade of the third interhemal and inserts on the anterior surfaces of the head of the ray. Its contraction erects the third ray and stabilizes the third interhemal, opposing the action of the muscle complex of the second ray.

CONCLUSION

There are numerous accounts dealing with modification of elements of the anal fin to form a gonopodium (see Rosen and Gordon, 1953), however, specialization of this fin as a clasping mechanism has not to my knowledge been reported among bony fishes.

Except for the "invasion" of the trunk region by the bones of the anal fin, evolution of the clasper described in this paper seems to be a rather uncomplicated matter.

From the description presented above, it can be seen that the greater the size of the male with respect to that of the female, the more effectively the clasper aids in copulation. It is interesting to consider the extent to which the trend of evolution of this species might be influenced by such a mechanism.

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Contributions to the Knowledge of the Alpheid Shrimp of the Pacific Ocean
Part I. Collections from the Mariana Archipelago[1]

ALBERT H. BANNER[2]

THIS IS THE FIRST of a planned series of papers on the distribution in the Pacific of the shrimp of the family Alpheidae (previously Crangonidae; name of the family and of the type genus, *Crangon*, changed by action of the International Commission for Zoological Nomenclature in February 1955, Opinion 334). A large series of collections has been made available to me. The collections were taken over a broad sweep of the Pacific, from the Tuamotus in the east to the Marianas in the west and I have supplemented these by personal collections. The series of publications will consider the collections archipelago by archipelago, and I hope to conclude them by a summarizing paper giving all citations to published works dealing with the Indo-Pacific species and full records of distribution for each species.

This work has been undertaken in the hope that these shrimp, the most common on the reefs, the most easily collected and preserved, may prove to be of value as zoogeographical and ecological "indicator organisms." Such indicator species could be used as they are used in plankton analyses to characterize and recognize certain ecological groupings correlated with the physical environment. At this early stage it is not known whether these species will prove of value in this respect.

Inasmuch as the concluding paper will carry all bibliographic citations to previous work in the Pacific, the individual papers will carry references only to the original descriptions of the species and to other papers used in the identification of the species.

The measurements used and the names of the ridges and grooves of the large chela in the genus *Alpheus* are the same as in my paper on the snapping shrimp of Hawaii (1953: 4, 59).

COLLECTIONS AVAILABLE

There are two major collections available from Saipan. The first I made while I was stationed there in the United States Army Air Force during the years 1944 and 1945. Unfortunately, world wars do not lend themselves well to biological collecting, and I was fortunate to be able to obtain as many specimens as I did. Perhaps half of the specimens I collected, together with all of my field notes on the localities and environments of the collections, were lost. As a consequence, I cannot assign the species to more than the general locality of Saipan. Most of my collections were made on the beach and narrow fringing reef called Unai Obyan; a few were made in various parts of the broad lagoon west of the island; none were made in Bahai

[1] Contribution No. 79, Hawaii Marine Laboratory. Manuscript received September 12, 1955.

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Laulau or on the north and east sides of the island because those areas were largely "out-of-bounds" with guerrilla action still taking place. The only station which I can positively identify is that for the collection dated 25 December 1944. It was made on the eastern side of the fringing reef before our camp, close to Cape Naftan; the water was about 3 feet deep within the "lagoon" of the fringing reef, the bottom was largely sand and extending above the water level were large boulders, upon the lower parts of which living coral was growing. This is the type locality for two new subspecies.

The other collection was made by Dr. Preston E. Cloud, Jr. and his party during the course of a geological survey of Saipan and is in the United States National Museum. Fortunately, there are thorough notes on the habitats of these specimens. The localities of the stations are shown in Figure 1; information on the habitats is given below:

A-5—1 mile offshore, depth 28 feet. Limes sand bottom surrounds areas of what appear to be bare coral-algal limestone in horizontal layers. Scattered over the surface of the rock patches and also on the limesand are irregular blocks of dead coral. Patches of bright orange sponge were observed, but neither living plants nor corals were noted. April 6, 1949.

A-7—1.2 miles offshore (immediately south of uncovering reef SE of Mañagaha islet); depth 24 feet. Even to very slightly undulating bottom of fine- to coarse-grained limesand. April 6, 1949.

C-1—About 1,200 feet offshore; depth 10 feet. Limesand plain, dominantly coarse-grained and well sorted, with minor reef prominences up to about 20 feet in diameter. April 9, 1949.

C-7a—About 1.4 miles offshore; depth 8–9 feet around coral-algal bosses that rise to or near surface along line of transverse. Between coral and coral-algal masses the bottom is thinly coated with limesand, through which one can scrape to a hard undersurface of crustose coralline algae with bare hands. April 10, 1949.

FIG. 1. Saipan, Mariana Archipelago, 13° 20′ N, 140° 40′ E, showing collecting stations. The geographical designations are given in the local, non-anglicized, names (courtesy of Dr. P. E. Cloud, Jr.). Outer dotted line represents 100 fathoms, inner dashed line 10 fathoms. (Adapted from U. S. Hydrographic Office Chart 6060.)

D-5—About 0.6 mile off Muchot point between reef clusters at south side of Saipan harbor; depth 5–15 feet. Generally similar to D-6 (see below), but with rocky bottom and a lesser total area of limesand nearby. Bottom at immediate point of collecting is one of mostly dead coral-algal rock with a fairly rich veneer of living crustose coralline algae. It rises to within five feet of the water surface at some places, but has deep cracks, channels, pothole-like depressions, and irregular depressions, some floored with angular gravel of broken coral and algal material. Into and cutting across this irregular rock surface are

limesand-floored channels up to perhaps 10 feet deep (15 feet below water surface) and for the most part sharply undercut into the base of the bordering overhanging coral-algal rock. May 6, 1949.

D-6—About 0.8 mile off Muchot point, near entrance to Saipan Harbor; depth 4–17 feet. Point of anchorage at a depth of 4 feet over the edge of a very irregular reef surface in which the primary builders of the present time are crustose coralline algae. Green algae are fairly abundantly scattered over the irregular reef surface, and into it extend tongues of clean limesand with ripple marks aligned approximately parallel to the reef front. These limesand tongues merge seaward with larger areas of limesand at depths of 15–17 feet. In pothole-like depressions on the reef surface are minor accumulations of angular gravel of broken coral and coralline algae. May 6, 1949.

D-7—About 1 mile off Muchot point, near entrance to Saipan Harbor; depth 22 feet. Collecting point immediately south of a mooring buoy over a narrow tongue of limesand between two rocky mounds—the one to the east rising about 12 feet above the bottom and being perhaps 100 yards long. Although drab and dead-looking, the surfaces of these and similar nearby mounds have a large proportion of living, purplish pink, crustose coralline algae. This calcareous algal growth, however, appears to be mostly a surface veneer over dead coral centers, a scattered growth of living coral still persisting in spots that have not been completely covered over by algae. May 6 and 13, 1949.

D-8—About 1.3 miles off Muchot point, immediately east of outer channel buoy, entrance to Saipan harbor; depth 36–42 feet. Bottom dominantly of dead coral-algal rock with irregular patches and thin local veneers of limesand and coral-algal rubble. Living coral and crustose coralline algae are found only as occasional bits on the generally dead and rocky surface, perhaps because of the general murkiness of the water here at the harbor exit. The individual rocky mounds are low, rising to an approximately consistent level only a few feet above the intervening limesand. May 13, June 26, 1949.

E-4—About 0.4 mile offshore; depth 5–9 feet. Bottom of calcareous gravel and coarse limesand, interspersed with patches of ramose coralline algae. May 3, 1949.

E-7—About 0.9 mile offshore just beyond seaward edge of south limb of barrier reef west of Saipan; depth 25–34 feet. Bottom is a rough and irregular rocky surface of dead coral and coral-algal material on which are occasional patches of veneering limesand. A few small patches of veneering coral were seen, and a little living coralline algae; but most of the floor is dead rock with a scattering of encrusting green algae. May 3, 1949.

E-8—About 1.1 miles offshore, just north of Schildkrote Rock, seaward from the barrier reef west of Saipan; depth 32–38 feet. Bottom is very rocky, rising abruptly to Schildkrote Rock, which has points within two feet of mean low tide. May 4, 1949.

FX—About 0.7 mile offshore, depth less than 6 feet at low tide. Calcareous gravel and limesand bottom at inboard edge of reef. April 18, 1949.

LOC. 2—North side of passage into Saipan harbor. Depths 40–45 feet over bottom of interspersed limesand and patch reefs. Specimens taken from a half-ton coral rock brought up on a ship's anchor and broken up with sledge hammers and picks. April 28, 1949.

LOC. 6—Just north of Mañagaha islet in lagoon west of Saipan. Collections from lagoon fringe of barrier reef. June 1949.

LOC. 8—In shoal water over broad fringing reef at northwest end of barrier–fringing reef complex west of Saipan. Depths less than 6 feet at low tide. Knolls of dead coral-algal rock and living corals common on calcareous gravel and limesand bottom. Various times between December 1948 and June 1949.

LOC. 9—Fanunchuluyan Bay at northeast end of Saipan. Sand and gravel platform covered by as much as 5 or 6 feet of water at low

tide and locally with numerous irregular bosses of coral-algal rock and patchy coral growth behind seaward edge of a fringing reef, 300 to 700 feet wide. December 25, 1948.

Further information on these stations and the marine ecology of Saipan may be found in Cloud's chapter, "Marine Geology and Shoal Water Ecology" in the forthcoming *Geology of Saipan*.

In addition to these two collections, there is one specimen reported in this study that was collected on Guam (about 100 miles south of Saipan) by a Mr. Seale in 1900 which is in the Bernice P. Bishop Museum of Honolulu.

Cloud's study on Saipan was made under the sponsorship of the United States Geological Survey and the Corps of Engineers, United States Army. The present study was begun with support from a grant administered by the United States National Museum and the Pacific Science Board under a contract between the Office of Naval Research, Biology Branch, and the National Academy of Sciences (NR160–175); some help in the final typing was obtained with funds from a National Science Foundation grant (NSF-G-1754).

The specimens collected by Cloud, together with the type specimens from my collection, will be deposited in the United States National Museum; the disposition of my personal collection has not yet been decided and it may be deposited either in the National Museum or in the Bernice P. Bishop Museum.

AUTOMATE de Man

Automate johnsoni Chace

Automate johnsoni Chace, U. S. Natl. Mus., Proc. 105 (3349): 13, fig. 7, 1955.

LOCALITIES: Banner, 2 specimens in 2 collections; Cloud 1 specimen each at D-8, E-7, E-8.

DISCUSSION: Of the five specimens in the collection, only one, an ovigerous female, had the chelae intact.

It is difficult to decide how these few fragmentary specimens should be named. *A. johnsoni* is at least very closely related to *A. gardineri* Coutiére (1905: 854), and, in the opinion of Chace, perhaps identical with it. In the series of slight differences between the two forms, the specimens from Saipan are somewhat intermediate, and appear to differ from both forms in yet other ways.

The rostrum in *A. gardineri* is rounded and separated laterally from the margins of the carapace by slight grooves, whereas in *A. johnsoni* and in the present specimens it is anteriorly rounded and without lateral grooves. The eyes in *A. gardineri* are variable in shape, but are irregular on the lateral and anterior margins according to the figures, whereas in *A. johnsoni* and the Saipan specimens the peduncles and corneas present a smooth curve from the base to the anterior medial margin. Chace points out that the second antennular article is 2.5 instead of 4.0 times as long as broad in his specimen; however, according to Coutiére's figures the proportions in his type and cotype vary from 3 to 4 times as long as broad, and he states in his text that the proportions vary with the size of the specimen; in the Saipan specimens the proportion is about 3 to 1. In both *A. gardineri* and these specimens the stylocerite does not reach to the end of the first article, and the scaphocerite does not reach past the middle of the second article of the antennules, whereas in *A. johnsoni* the stylocerite exceeds the first article in length and the scaphocerite reaches within 0.2 of the end of the second article. Further, the superior surface of the ischium of the large chela bears a strong spine in the Saipan specimens, a weak spine in *A. johnsoni*, and lacks a spine (according to the figures) in *A. gardineri;* neither Coutiére nor Chace show or discuss any rounded teeth on the dactylus of the large chela, yet they are quite easily seen on the chela of these Saipan specimens. Finally, in the second legs the first two articles are shown to have a ratio of 10:18 by Coutiére, 10:12 by Chace, and are about 10:13

in the Saipan specimens (the right and left carpi have slightly different proportions in the distal articles of the intact female).

I suspect that the differences between *A. gardineri*, *A. johnsoni*, and the Saipan specimens are either individual variations or geographic differences of only subspecific worth, but until more complete specimens are examined from other areas, it would be best to leave the two species standing. These specimens from Saipan have been placed in *A. johnsoni* because of the similarity of the anterior carapace and rostrum.

ATHANAS Leach

Athanas djiboutensis Coutière

Athanas djiboutensis Coutière, Paris Mus. d'Hist. Nat., Bul. 3(6): 234, 1897*a;* Soc. Philomath. Paris, Bul. IX, 5(2): 75, 1903, *and* Fauna and Geogr. Mald. and Laccad. 2(4): 856, 1905. [These two identical papers are partial redescriptions.]

Athanas sulcatipes Borradaile, Zool. Soc. London, Proc., [1898]: 1011, pl. 65, fig. 9, 1898.

LOCALITIES: Banner, 22 specimens in 6 collections. Cloud, 3 at locality A-5, 1 at A-7, 3 at C-7a (13 May 1949), 2 at D-5, 2 at Loc. 8, 1 at Loc. 6.

DISCUSSION: These specimens agree well with the original and the redescription of Coutière, except for several points of variation both of which have been remarked upon before by Tattersall (1921: 367–368). The first is the length of the rostrum in respect to the antennular peduncle, described by Coutière (1905) as reaching "presque l'extrémité du pédoncule antennulaire"; in this large series of specimens only few approach this length, while most reach to near the end of the second antennular article and a few reach only the middle of the same article. A second point of variation is found in the form and armature of the large chela of the males. On this appendage the ischium bears from one (as shown by Coutière) to four strong movable spines; the outer inferior margin of the merus may be entire, bear a slight rounded indentation, or be divided into two shallow and broad lobes, the distal approximately half the length of the proximal; the palm of the chela proper varies, being both slightly thicker and less tapering than is shown by Coutière, and, in proportion to the fingers, the palm is relatively longer; finally, the dactylus may be strongly curved and cross the immovable fingers as shown by Coutière, or be less curved and meet the opposite exactly. The conical protuberance of the carpus of the small chela of the female may be lacking and the surface of the carpus away from the chela may be rounded. No great significance is attached to these variations, especially as they have been previously noted by Tattersall, and as the variations appear independently of each other in the individual specimens.

The eyes appear to have some degree of motion, they may be either extended from under the carapace or withdrawn slightly. This small motion would not be noteworthy except that in this species and in other members of this genus the lengths of the circumorbital spines are often compared relative to these corneas as part of the specific description.

Athanas dubius sp. nov.
Fig. 2

TYPES: Holotype a 7.3 mm. ovigerous female, collected from Saipan by A. H. Banner; allotype a male 7.8 mm. long and 7 paratypes collected by A. H. Banner in three collections; 1 paratype collected by P. E. Cloud, Jr., from locality E-8. Types to be deposited in the U. S. National Museum.

DESCRIPTION: Rostrum acute, triangular, sides not curved, tip reaching to end of second antennular article (Fig. 2*a* has somewhat foreshortened rostrum); rostrum and carapace rounded, without carina. Supracorneal spines not reaching to middle of cornea; carapace between base of supracorneal spines and ros-

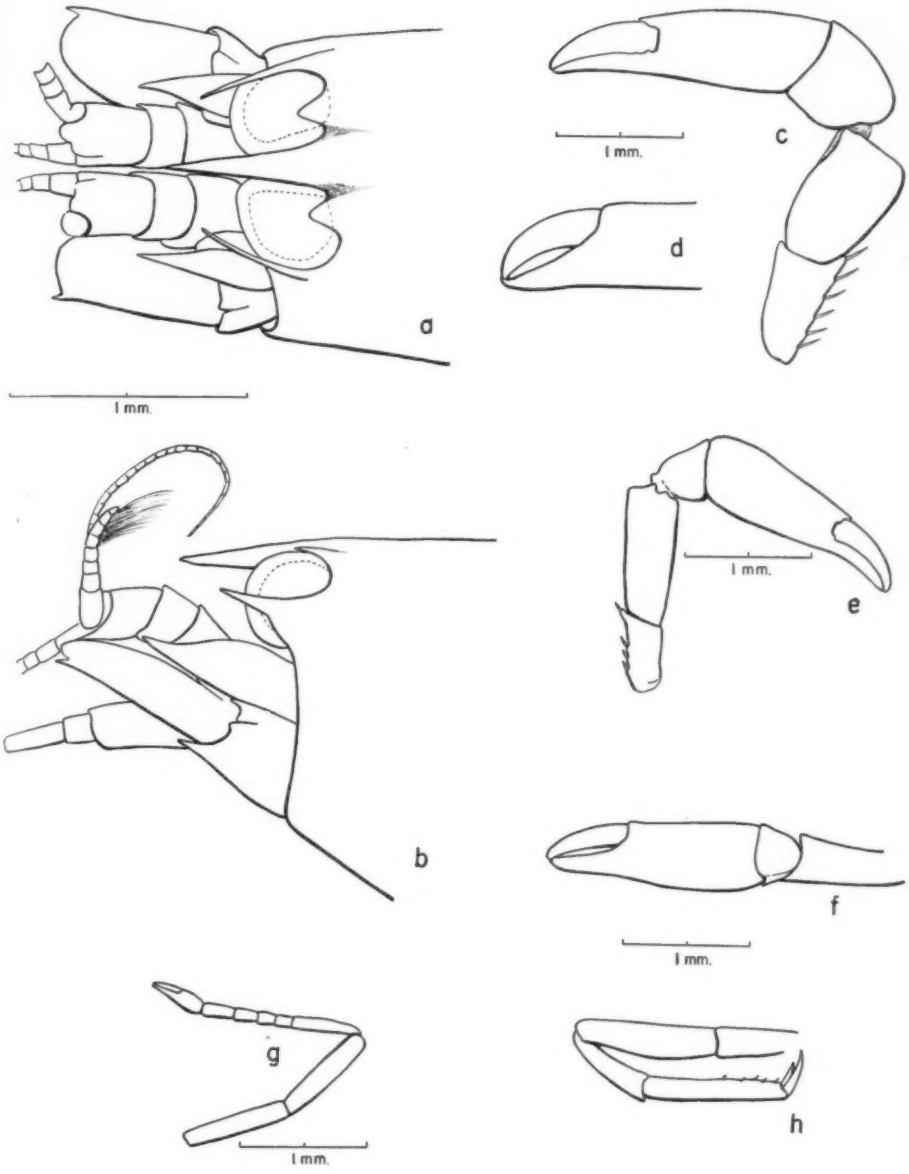

FIG. 2. *Athanas dubius* sp. nov. *a*, *b*, Anterior region, dorsal and lateral aspects; *c*, cheliped, male; *d*, large chela, finger, male; *e*, cheliped, female; *f*, chela, propodus and merus, female; *g*, second leg; *h*, third leg.

trum slightly depressed. Extracorneal spines strong, acute, reaching beyond corneas almost to end of first antennular article. Infracorneal spine absent, represented by a slight convexity on inferior margin of extracorneal spine. Pterygostomial angle rounded.

Portion of first antennular article in front of corneas about equal in length to second antennular article, latter about half as long as third article. Stylocerite acute, reaching end of second article. Lateral spine of basicerite reaching end of first antennular article. Scaphocerite with lateral spine very slightly longer than rounded portion, reaching slightly beyond end of antennular peduncle. Carpocerite shorter than scaphocerite.

Chelipeds showing slight sexual dimorphism and, in some cases, asymmetry. In type (female), large chela about 7 per cent longer than small chela, both of similar form. Ischium bearing four strong spines; merus unarmed, about 2.5 times as long as broad; carpus rounded, somewhat elongate, with distal end enclosing base of palm; chela almost cylindrical, slightly inflated proximally, three times as long as broad, with fingers occupying about distal third; fingers without teeth, dactylus slightly curved. Large chela in allotype slightly over 10 per cent longer than small chela, but of similar form. Ischium 0.8 as long as merus and bearing six strong spines; merus heavy, 0.6 as broad as long, half as long as chela, unarmed; carpus heavy, cylindrical and fitting over base of chela; chela cylindrical, tapering, 0.3 as broad as long, with fingers occupying slightly less than distal third; fingers unarmed, dactylus curved distally.

Carpal articles with ratio: 10: 2.6: 3.2: 3.7: 5.9.

Ischium of third legs unarmed, 0.5 as long as merus; merus unarmed, 0.2 as broad as long; carpus 0.6 as long as merus, 3 times as long as broad; propodus equal in length to merus, bearing 5 small spinules in distal half, terminal movable spine 0.6 length of dactylus; dactylus 0.3 length of propodus, simple, slightly curved and gradually tapering to acute tip.

Telson half as wide posteriorly as anteriorly, 3.6 times as long as posterior margin is broad; sides straight with uniform taper; distal margin moderately convex; both dorsal spinules located posterior to middle.

Eggs of type specimen 0.32 × 0.50 mm. in diameter.

DISCUSSION: In the group of paratypic specimens some variations are found, especially in the armature of the chelipeds. The number of spines on the ischium in the females varies from three to six, usually five or six; in the males the spines, always stronger than those of the female, vary in number from five to six. In some of the males the distal external angle of the merus is produced into a strong but rounded lobe; in one female the superior angle of the distal end of the merus carries a rather weak movable spine. Further, the degree of asymmetry varies from chelae that are equal to to slightly more asymmetrical than those of the types. Finally, on one female the carpus of the second legs on one side is divided into four articles while the other has the normal five. No marked variation was noticed in the other parts of the body or appendages.

The validity of this species is somewhat questionable for it is closely associated with *A. areteformis* Coutière (1903: 79; 1905: 860) and *A. erythraeus* Ramadam (1936: 13). Unfortunately the description of neither of these two species is complete. All three belong to the *nitescens* group of the genus in which the chelae are carried directed forward. All three also have simple dactyli on the posterior legs, the supracorneal spine well developed, the extracorneal spine greatly produced, and the infracorneal spine wanting. *A. dubius* differs from *A. areteformis* in that the dactylus of the large chela of the male is relatively longer, being over 0.6 the length of the palm in the former and 0.3 the length of the palm in the latter; in the latter, moreover, this dactylus is strongly curved. In comparing the chelae

of the female of *A. dubius* to *A. naifaroensis* (which Coutière states ". . . ne diffère aucunement. . . .") it is found that the palm is less expanded in *A. naifaroensis*, being without taper and having its breadth equal to only half the length of the fingers, instead of being equal to the length of the fingers as in *A. dubius*, also the ischium is unarmed in *A. naifaroensis* whereas in *A. dubius* it bears 3–6 spines.

There are also slight differences between *A. dubius* and *A. erythraeus*. Ramadam states that in the latter the sides of the rostrum are parallel for some distance from the proximal end, whereas in the former there is a uniform taper from the base to the tip; in his specimen, a female, the fingers of the chela have slightly rounded teeth, two on the side of the dactyl, one on the immovable finger, and in mine the fingers bear straight knife-like cutting edges.

However, these differences, and the differences between *A. erythraeus* and *A. areteformis*, are very slight, and the similarities, especially in the form of the anterior carapace and appendages, are great. It is reasonable to expect that when specimens are collected at localities between Ghardaqa in the Red Sea and the Maldive and Laccadive archipelagoes in the Indian Ocean and between these archipelagoes and the Marianas, intermediate forms may be found.

ARETE Stimpson

Arete iphianassa de Man

Arete iphianassa de Man, Ned. Dierk. Ver., Tidschr. II, 11(4): 312, 1910; Siboga Exped., 39a[1](2): 164, pls. 3–4, fig. 11, 1911.

LOCALITIES: Cloud, 4 specimens at locality C-7a (2 each on 10 April and 13 May, 1949), 1 at D-8, 1 at Loc. 6.

DISCUSSION: These six specimens agree almost exactly with de Man's description and figures except that the tooth on the dactylus of the large chela of the male is less pronounced than shown in de Man's figure 11a.

ALPHEOPSIS Coutière

Alpheopsis equalis Coutière

Alpheopsis equalis Coutière, Paris Mus. d'Hist. Nat., Bul. 2(8): 380, 1896.

Alpheopsis aequalis de Man, Siboga Exped., 39a[1] (2): 177, 1911.

LOCALITIES: Banner, 17 specimens in 5 collections: Cloud, 1 specimen at Loc. 6.

DISCUSSION: These specimens show much of the variation in the rostrum, pterygostomial angle, coverage of the eyes, and in the large chelae like that already reported from Hawaii (Banner, 1953: 16). In addition they present several variations worthy of note. First, the base of the rostrum in most specimens is set off from the anterior portion of the carapace by definite angles, but in one specimen the margins of the carapace are continuous in a gradual concave curve to the tip of the rostrum, and in several specimens the condition is intermediate, Second, the ratio of the middle articles of the carpus is also variable, with the second article running from a third shorter to a third longer than the third article; the ratio of the lengths of the third and fourth articles also varies but less conspicuously. Finally, in a specimen normal in all other respects the carpus of the second leg is divided into six, rather than five articles. This development is symmetric, and the extra article appears to be equal in length to the normal third article and is adjacent (either proximal or distal) to it.

Alpheopsis diabilus, sp. nov.
Fig. 3

TYPE: A 9.2 mm. ovigerous female, collected by A. H. Banner.

DESCRIPTION: Anterior portion of carapace produced as short, triangular rostrum reaching two-thirds of length of visible portion of first antennular article, and as triangular extracorneal spines about half the length of rostrum; without ridges or depressions. Pigmented portion of cornea concealed in dorsal

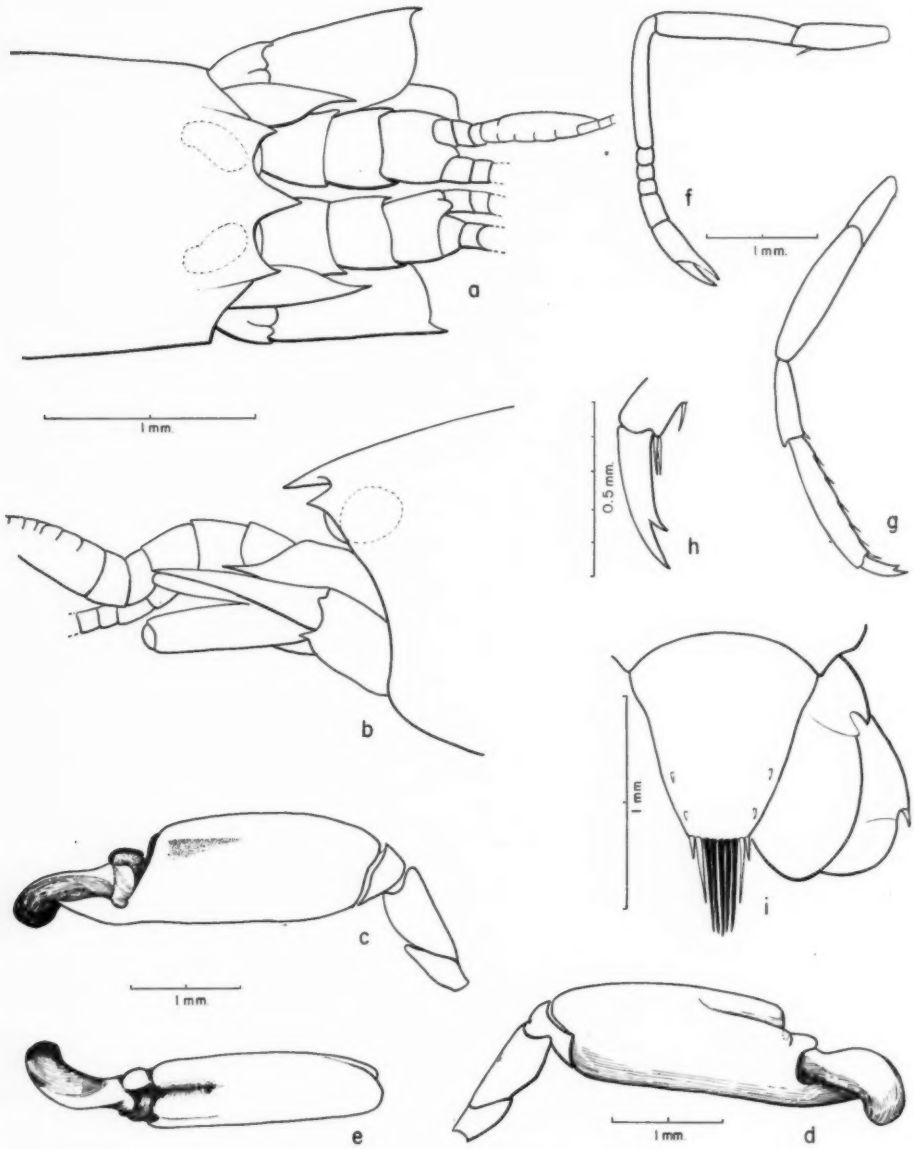

FIG. 3. *Alpheopsis diabolus* sp. nov. *a*, *b*, Anterior region, dorsal and lateral aspects; *c–e*, large cheliped, lateral, medial and superior aspects; *f*, second leg; *g*, third leg; *h*, third leg, dactylus; *i*, telson and uropod.

and lateral view, but outer margin of eyes visible in both aspects. Pterygostomial angle rounded.

Visible portion of first antennular article 1.3 times length of second article; second article approximately as long as third article and slightly broader than long; stylocerite acute with tip reaching to middle of second article; outer flagellum with basal portion before bifurcation very broad; bifurcation feeble. Basicerite of antennal peduncle with distal lateral tooth; scaphocerite with strong distal lateral tooth, slightly exceeding the length of rounded portion, subequal in length to antennular peduncle; carpocerite slightly longer than scaphocerite.

Merus of large cheliped as broad as inferior margin is long, subequal to maximum length of ischium; ischium and merus unarmed. Carpus short, rounded, with triangular projection on middle of inner margin. Chela compressed, superior and inferior margins rounded. Palm twice as long as ischium and merus combined, slightly over twice as long as broad; outer face with shallow rounded groove extending from dactylar articulation one-third length of palm; superior face marked by deep groove separating two sharp ridges, equal in length to lateral groove. Dactylus articulated to close about 60° to plane of chela, across pointed fixed finger; superior articular surface of propodus carried in rounded prominence beyond crests and grooves of palm to accommodate rotation. Dactylus broad, curved and flattened, without teeth, 0.4 length of palm. Only small tufts of setae located near fingers on chela.

Small cheliped lacking.

Carpus of second legs with ratio: 10: 1.5: 1.5: 1.5: 2.; short articles about as long as broad.

Second legs with ischium unarmed; merus 2.3 times length of ischium and 4.5 times as long as broad, unarmed; carpus 0.5 length of merus, with small movable spine on inferior distal angle; propodus as long as merus, armed with five inferior and two distal slender spines; dactylus 0.3 length of propodus, with strong accessory tooth on inferior margin.

Pleura of sixth abdominal segment articulated.

Telson short and broad, 3.2 times as long as tip is broad, 3.0 times as broad anteriorly as at tip; tip almost straight, bearing two pair of spines, five heavy setae; longer spines three times as long as shorter, equal in length to breadth of tip of telson; anterior pair of dorsal spinules located about 0.7, posterior pair about 0.85 distance from base of telson, both pairs located near lateral margins. Outer uropod with strong spine at articulation; both uropods longer than telson.

Branchial formula with five pleurobranchs, one arthrobranch and eight epipodites.

Eggs few, 0.62 × 0.36 mm. in diameter.

DISCUSSION: This species plainly belongs to the genus *Alpheopsis* as is shown by the articulated pleopods of the sixth abdominal segment, by the general form of the anterior portion of the carapace and by the branchial formula. The form of the chela is somewhat similar to that of *A. trispinosus* (Stimpson) and *A. chilensis* Coutière (see Coutière, 1899, figs. 228–232).

Within the genus, however, it differs from all other forms except *A. fissipes* Coutière and (?) *A. biunguiculatus* Banner in the presence of biunguiculate dactyli on the third to fifth legs. From *A. fissipes* it differs principally in the presence of extracorneal teeth, the greatly elongate first carpal article of the second leg, and the difference in proportions and armature of the third legs. Similarly, it differs from (?) *A. biunguiculatus* in the extracorneal teeth, the carpus of the second legs, and the armature of the propodus of the third legs; it also differs in the branchial formula and the form of the telson. (In neither of these species are the chelae known.) As far as I have been able to determine, the form of the large chela, with the double grooves and the rotation of the flattened and unarmed dactylus is unique within the genus; however, in many of the species the chelae have not been described.

This specific name refers to the split unguis.

Alpheopsis tetrarthri sp. nov.
Fig. 4

TYPE: A 6.0 mm. female collected from a head of dead coral at Loc. 2 by Preston E. Cloud, Jr., 28 April 1949. Type to be deposited in the U. S. National Museum.

DESCRIPTION: Anterior carapace projecting as a broad curved collar, reaching almost to end of first article of antennular peduncle; anterior margin uniformly curved; dorsal surface smooth, without ridges or bosses. Rostrum small, triangular in dorsal view, tip reaching about to end of first third of second antennular article; in lateral view appears to be composed of a lamella hanging ventral to carapace proper, tip strongly depressed. Pterygostomial angle projecting as acute spine; no other spines of anterior carapace developed.

Cornea of eyes large, entirely concealed from dorsal and lateral view by carapace.

Antennular peduncle short, heavy, with second article about as broad as long, approximately as long as third article; first article barely visible under projecting edge of carapace. Stylocerite acute, reaching to middle of second article, slightly beyond tip of rostrum. Flagella of usual size, about twice as long as peduncle. External flagellum with broad base bearing tuft of long bristles, but without trace of bifurcation.

Basicerite of antennal peduncle without tooth. Scaphocerite broad, well developed, with lateral spine small, reaching anterior tip of curved portion; tip of scaphocerite definitely exceeding antennular peduncle in

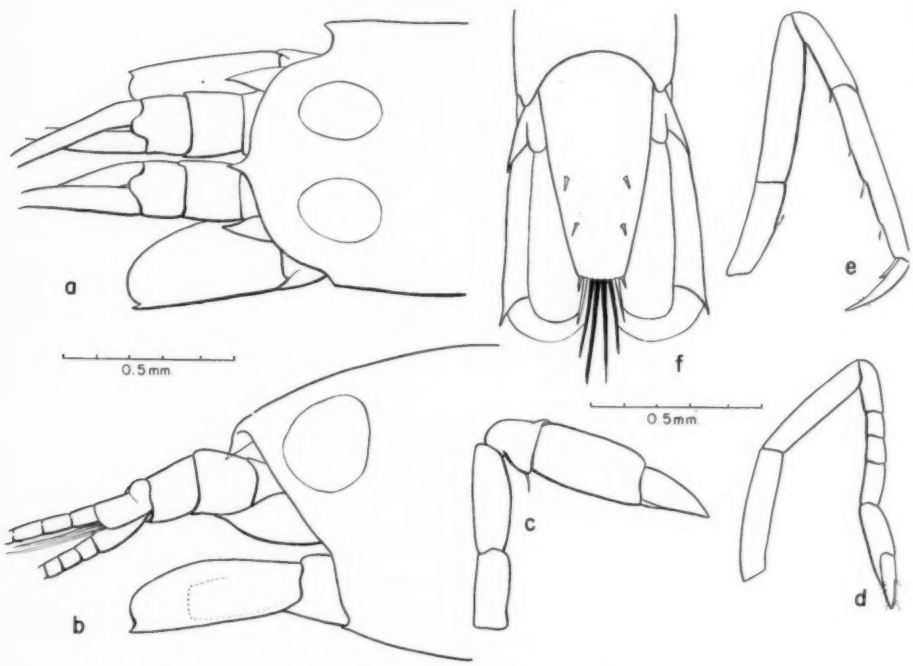

FIG. 4. *Alpheopsis tetrarthri* sp. nov. *a*, *b*, Anterior region, dorsal and lateral views (outline of distal portion of carpocerite dotted in *b*); *c*, cheliped; *d*, second leg; *e*, third leg; *f*, telson and uropods.

length. Carpocerite short, reaching only slightly beyond end of second antennular article.

Mouthparts not dissected.

One of first chelipeds lost. Chela of leg remaining small, as long as ischium and merus combined; palm about twice as long as broad, 1.5 times as long as tapering slender fingers. Carpus as broad as long, slightly cyanthiform distally. Merus rounded-triangular in section, about 2.5 times as long as broad. Ischium 0.7 as long as merus, of same width.

Second legs with carpus of only four articles with ratio: 10: 5: 7: 9. Chela relatively large, as long as merus.

Third, fourth, fifth legs similar. On fourth leg ischium 0.6 as long as merus, bearing movable spine; merus five times as long as broad, unarmed; carpus half as long as merus; propodus slightly longer than merus, bearing three slender spines on inferior margin, one distally; dactylus half as long as merus, slender, tapering to fine tip.

Pleura of sixth abdominal segment articulated.

Telson twice as long as broad anteriorly, with tip 0.4 as broad as base; two pairs of dorsal spines, anterior located at half length of telson, posterior midway between anterior pair and tip; tip shallowly arcuate, bearing four spines, longer pair as long as tip of telson is broad, four heavy setae. Uropods of usual form.

Branchiae difficult to discern, but apparently with five pleurobranchs, arthrobranchs either rudimentary or entirely lacking; seven or possibly eight epipodites.

DISCUSSION: Unfortunately this species is represented by a single defective specimen, possibly also immature. It appears to belong to the genus *Alpheopsis*. The form of the carapace and rostrum are similar to that of *Alpheopsis equalis* except that the carapace extends much farther forward and the rostrum is relatively smaller; the antennular and antennal peduncles are of the same general form as *A. equalis* but of slightly different proportions; the small chela is almost identical to the small chela of *A. equalis*, as are the third and fourth legs; the telson and uropods, and the articulated sixth pleopods of the abdomen are also similar. The principal differences between *tetrarthri* and the other species of the genus are the presence of four articles in the carpus of the second leg in this species whereas in the others there are either three articles (*A. idiocarpus* Coutière) or five and a difference in the branchial formula which in this species is apparently 5–0–7, instead of 5–1–6 or 5–1–8. (It should be noted that (?) *Alpheopsis biunguiculus* Banner (1953: 19) has a rudimentary arthrobranch and only seven epipodites.) The species is assigned to this genus in spite of these possible fundamental differences because it has been accepted already that the number of articles in the carpus is not fixed in this genus, and because I could not determine the branchial formula to my satisfaction without tearing this unique specimen apart. Without the large chela, even if all the other characteristics were in complete agreement, any generic identification would be tentative.

Within the genus *Alpheopsis* this species can be separated readily from all other species by the presence of only four articles in the carpus of the second leg and by the extreme prolongation of the anterior margin of the carapace. Other minor differences occur between *tetrarthri* and the other species such as the proportions of the stylocerite and antennular peduncle; the proportions of the scaphocerite and antennal peduncle; the simple or bifid dactylus of the third legs; and the proportions of the telson.

SYNALPHEUS Bate
Neomeris group

Synalpheus charon obscurus, subsp. nov.

Fig. 5

Alpheus charon Heller, K. Akad. Wiss. Wien, Sitzungber. 44: 272, 1861.

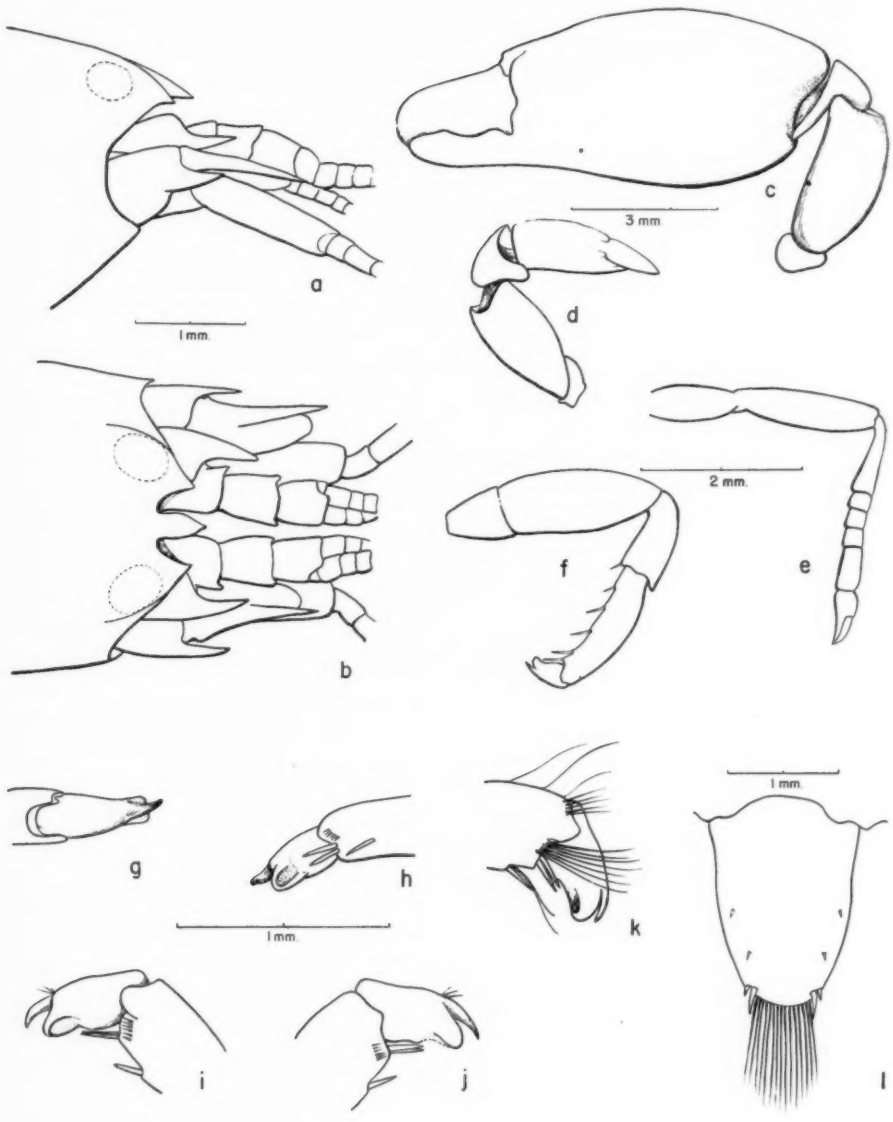

FIG. 5. *Synalpheus charon obscurus* subsp. nov. *a*, *b*, Anterior region, dorsal and lateral aspects; *c*, large cheliped; *d*, small cheliped; *e*, second leg; *f*, third leg; *g*, *h*, *i*, *j*, dactylus, third leg, superior, inferior, medial or anterior, and lateral or posterior aspects; *k*, dactylus, fourth leg; *l*, telson.

TYPES: Holotype a 13.5 mm. ovigerous female, collected by A. H. Banner from the reef flat on the S. E. side of Unai Obyan, Saipan, 25 December 1944; allotype, a 9.3 mm. male from the same location; paratypes, 14 other specimens from three collections, A. H. Banner, collector.

DESCRIPTION: Body heavy, compact. Rostrum with basal portion parallel sided, slightly over distal third tapering, tip acute, not reaching end of first antennular article. Orbital hoods acuminate, tips of orbital teeth not reaching end of rostrum.

First and second articles of antennular peduncle subequal in length, third slightly shorter. Stylocerite heavy, tip reaching to middle of second antennular article. Lateral spine of basicerite heavy, slightly shorter than stylocerite. Lateral tooth of scaphocerite as long as antennular peduncle, definitely longer than the squamous flattened portion.

Merus of large cheliped unarmed, slightly curved, twice as long as broad. Chela 2.5 times as long as broad, with heavy fingers occupying distal 0.28; superolateral margin of palm continued over dactylar articulation as slight rounded tooth. Merus of small cheliped likewise unarmed; carpus slightly greater in diameter than palm of chela. Chela small, 0.3 the length of the large chela, 0.3 times as broad as long, with fingers occupying distal 0.4.

Carpal articles of second legs with ratio: 10:2.3:2.7:2.7:6.2.

Ischium of third legs unarmed, about one third as long as merus; merus unarmed, 2.4 times as long as broad; carpus half as long as merus, armed with single movable spine on inferodistal angle; propodus 0.8 as long as merus, bearing four inferior and two distal spines; dactylus heavy, with superior unguis simple, tapering, inferior unguis massive, concave on inferior surface; dactylus may or may not be flanked with long setae arising from distal end of propodus.

Telson 2.8 times as long as posterior margin is broad, and 2.0 times as wide anteriorly as posteriorly; margins without uniform taper, but concave in anterior third, convex in middle third and almost straight (but not parallel) in distal third. Dorsal spinules small.

Eggs numerous, 0.41 × 0.63 in diameter.

Male similar to female in form and proportions.

DISCUSSION: This subspecies can be separated from the typical subspecies, *S. charon charon*, by the following characteristics: *1*, The rostrum is parallel-sided in at least the basal half rather than uniformly tapered. *2*, The meri of the third legs, are 2.4 instead of 3.0 times as long as broad. *3*, The superior unguis of the dactyli of the third legs is not as broad basally and has a uniform taper to the tip rather than with a broad basal plate which is abruptly narrowed to a curved tip. Otherwise the two varieties are almost identical aside from minor and insignificant differences in the proportions of the second legs, telson, etc.

Because of the unique concavity of the dactyls of the posterior legs, found only in *S. charon* in this genus, it was considered that this form is merely a subspecific modification. On Saipan no true *S. charon charon* were collected; however, in the Gilbert Islands both subspecies were found (to be reported upon in a later publication).

Synalpheus paraneomeris Coutière
Fig. 6

Synalpheus paraneomeris Coutière, Fauna and Geog. Mald. and Laccad. 2(4): 872, pl. 71, fig. 7, 1905.

LOCALITIES: Banner, 64 specimens in 6 collections; Cloud, 19 specimens at Loc. D-6, 8 at Loc. 6.

DISCUSSION: The variation in this species has been discussed by Coutière (*loc. cit.*) and Banner (1953: 40 *et seq.*). The great variation noticed in the Hawaiian specimens is duplicated and even exceeded in the specimens from Saipan. Like the Hawaiian specimens, they vary in the length of the rostrum relative

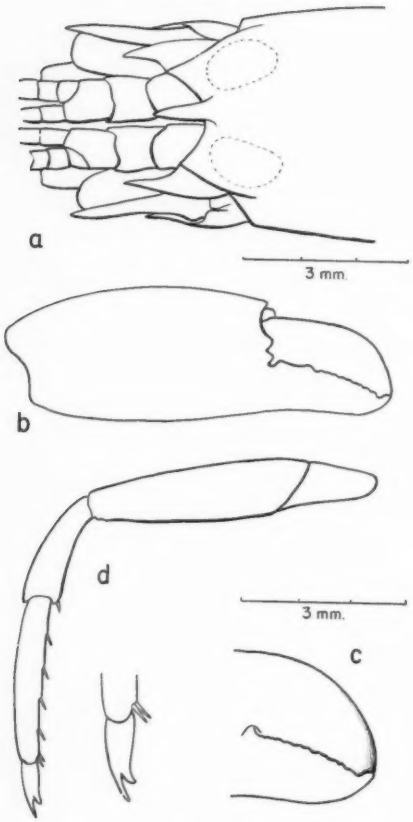

FIG. 6. *Synalpheus paraneomeris* Coutière. Aberrant specimen. *a*, Anterior region, dorsal aspect, showing asymmetry in orbital hoods; *b*, large chela, lateral aspect; *c*, large chela, fingers, showing details of teeth; *d*, third leg; *e*, third leg, dactylus enlarged.

to the orbital teeth and antennular peduncle, in the antennular peduncle, in the basicerite and scaphocerite of the antennal peduncle, in the large cheliped, in the relative lengths of the carpal articles of the second legs, in the dactyli of the third legs, in the general proportions of the telson. In addition, variations occur in the relative length of the carpocerite, which varies from only slightly longer to considerably longer than the scaphocerite, and in the rostrum and in the large cheliped.

In the 19 specimens from Cloud's collection D-6 the length of the rostrum relative to the lengths of the orbital hoods, and its relative breadth were measured. (In one specimen the rostrum was entirely lacking, a condition interpreted as the result of an accident of heredity or environment.) The ratio of rostral length to orbital hood length ranged from 1:1 to 1.6:1, with the following distribution:

ROSTRAL LENGTH ÷ LENGTH ORBITAL HOOD	SPECIMENS
1.0	3
1.1	4
1.2	4
1.3	2
1.4	1
1.5	0
1.6	4

ROSTRAL LENGTH ÷ ROSTRAL WIDTH AT BASE	SPECIMENS
1.5	3
2.0–2.9	6
3.0–3.9	7
4.0–4.5	2

In a collection of 25 specimens made by the author, a series of specimens in which all chelae were intact, the relative lengths of the fingers were measured, and these measurements correlated with the sex of the specimens and are tabulated below:

CHELA LENGTH ÷ FINGER LENGTH	SPECIMENS	
	Male	Female
2.9	2	
3.0	2	
3.1		
3.2	1	1 (?)
3.3		
3.4		
3.5	1	2
3.6		3
3.7		4
3.8		3
3.9		1
4.0	1 (?)	2
4.1		
4.2		2

The interpretation of this second series of variations is simple: the length of the fingers relative to the chela is a sexually dimorphic

characteristic. (It should be remarked that males in other samples from Saipan had a ratio as low as 2.8:1.) The interpretation of the variations in the rostrum is more difficult, especially in view of the four specimens which seem so different in having the rostrum 1.6 times as long as the orbital hoods. However, these four specimens did not bear correlating difference in their other characteristics; for example, their rostral width ratios were 1.6, 1.6, 3.3, and 4.3, or, in words, two had very broad rostrums, one average, and one very narrow. So it would appear that this, too, was merely a variation.

In one collection there are two males with the chela:finger ratio of 3.0:1 in which the cutting edge of the fixed finger had shallow denticulations. One of these specimens is shown in Figure 6. The specimens are within the range of variation for the species, although the unguis of the dactylus of the third legs is a bit narrower and more parallel-sided than is usual for the species.

This species is the most perplexing I have encountered. If such wide variation is found here, why do other species appear to be so constant? Then, should not this be interpreted as more than one species? If the variations were discontinuous, or even if the variations were continuous, but their continuity could be established only by samples from separate localities or habitats—if, for example, those with the short rostrums were only found in the Marianas, those with long rostrums in Hawaii, and those in the intermediate condition were found in Micronesia—then descriptions of separate subspecies or species would be justified. But such separation seems unjustified when the range of variation is found in one habitat and in specimens collected at one time. If such variation is found in *S. paraneomeris*, should not similar variation be looked for in other species which are separated by small, but discrete, differences? For example, *S. biunguiculatus* (Stimpson) (as redescribed by Banner, 1953: 33) basically is separated from this species by the relatively smaller lower unguis of the dactylus of the third leg—could not this, too, be an inherent variation that may be ignored by a breeding population? I fear that the answer to this fundamental question can be arrived at only by the almost impossible task of raising the shrimp through several generations.

Coutierei Group

Synalpheus coutierei exilipes Coutière

Fig. 7

Synalpheus biunguiculatus var. *exilipes* Coutière, Fauna and Geog. Mald. and Laccad. 2(4): 874, pl. 71, fig. 10, 1905. [*nec. Alpheus biunguiculatus* Stimpson, Acad. Nat. Sci., Phila., Proc. 1860: 31] *Synalpheus coutierei* Banner, Pacific Sci. 7(1): 36, 1953.

LOCALITY: Cloud, an 8.5 mm. ovigerous female collected at Loc. 6.

DESCRIPTION: Rostrum narrow, tapering, suddenly acute at tip, tip reaching almost to end of first antennular article. Orbital teeth narrow, tapering, slightly shorter than rostrum; orbital hoods slightly inflated anteriorly.

Second antennular article 1.4 times as long as broad, or as long as first article, and one third longer than third article. Stylocerite as long as first antennular article and as lateral spine of basicerite. Basicerite with superior lateral angle projecting as small acute tooth. Scaphocerite as long as antennular peduncle. Carpocerite 6.5 times as long as broad in lateral view, tip reaching beyond end of antennular peduncle.

Large chela of usual shape for genus, 2.7 times as long as broad, with fingers occupying distal 0.2. Merus twice as long as broad, superior margin slightly arcuate and terminating in feeble tooth. Small chela with fingers tapering, occupying distal 0.4.

First carpal article of second leg equal to the sum of the lengths of the four following; second, third, and fourth articles subequal;

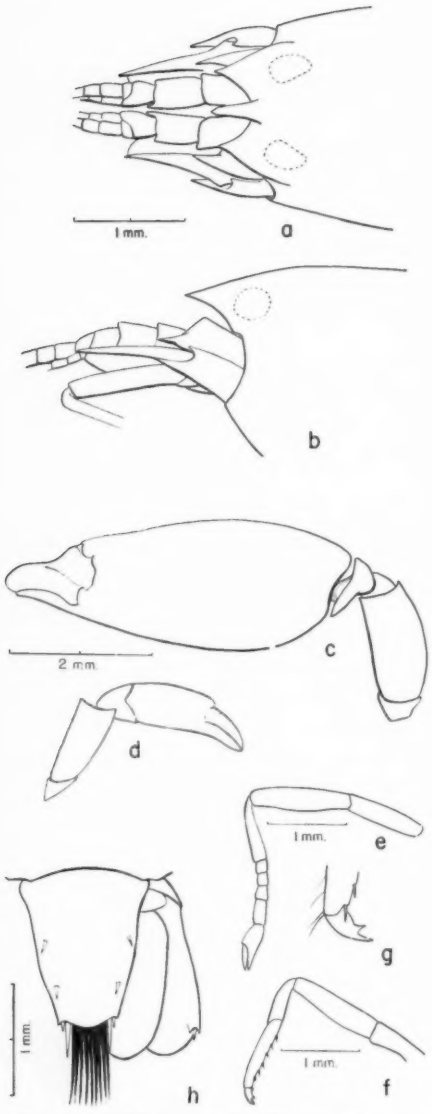

FIG. 7. *Synalpheus coutierei exilipes* Coutière. *a*, *b*, Anterior region, dorsal and lateral aspects; *c*, large cheliped; *d*, small cheliped; *e*, second leg; *f*, third leg, *g*, third leg, dactylus; *h*, telson and uropods.

fifth article slightly shorter than the lengths third and fourth combined.

Merus of third legs unarmed, tapering distally, 4.0 times as long as broad. Carpus 0.38 as long as merus, with superior margin terminated by tooth. Propodus 0.8 as long as merus, bearing six inferior and two terminal weak spines. Dactylus about 0.25 as long as of propodus, heavy, with superior unguis thin, curved and acute, inferior unguis at about 90° to inferior margin of dactyl, triangular, acute and broader at base than superior unguis.

Telson 2.7 times as long as posterior margin is broad, 2.2 times as broad anteriorly as posteriorly; lateral margins as shown in Figure 7*b;* posteriolateral angles slightly projecting and acute; posterior margin arcuate. Anterior pair of dorsal spinules slightly before the middle, posterior pair 0.8 of length posterior from base.

DISCUSSION: This specimen shows a series of differences from Coutière's subspecies (or variety). The rostrum and the orbital teeth are slightly shorter, the first antennular article is slightly longer, the lateral spines of the stylocerite and the basicerite are slightly shorter. Coutière did not describe the large and small chelae, but if the large chela bore a tooth as did his *S. biunguiculatus* (*op. cit.*, fig. 8a), there, too, lies a difference. However, the proportions of the third legs are almost exactly the same with the depicted dactyli varying on either side of the condition found here.

Certainly the two forms are not identical but they are so similar that in light of the variation in *S. paraneomeris* Coutière, nore gat importance should be attached to the slight differences. However, it is possible that if there were a series of specimens available the differences would be found to be constant enough to consider this as a distinct subspecies.

Synalpheus anceps sp. nov.
Fig. 8

TYPES: Holotype, an ovigerous 9.5 mm. female, collected from Saipan by A. H. Banner. Allotype, a 7.3 mm. male; paratypes, 13 specimens of both sexes, all collected by

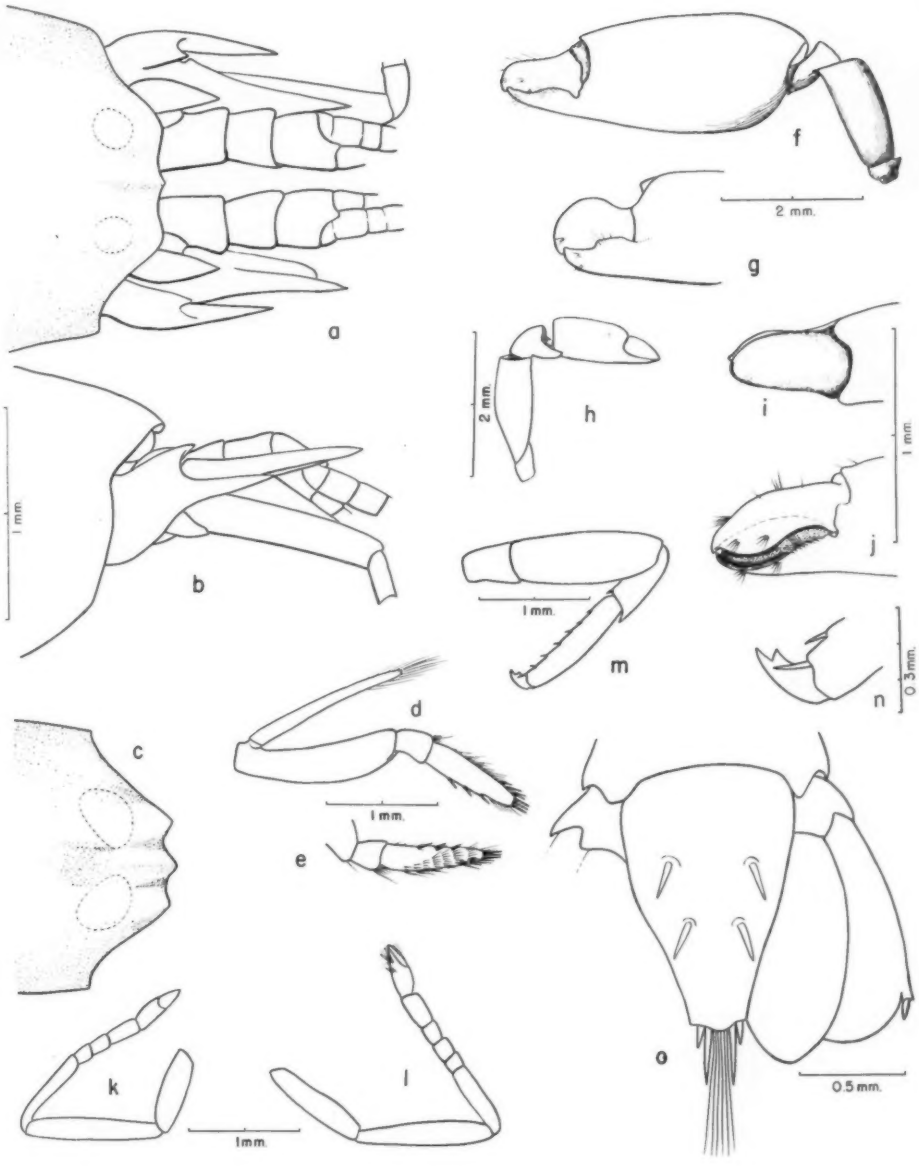

FIG. 8. *Synalpheus anceps* sp. nov. *a*, *b*, Anterior region, dorsal and lateral aspects; *c*, anterior region, another specimen; *d*, *e*, third maxilliped; *f*, *g*, large cheliped; *h*, small cheliped; *i*, spatulate dactylus of small cheliped, type; *j*, same, paratypic female; *k*, second leg, right side; *l*, same, left side; *m*, third leg; *n*, third leg, dactylus; *o*, telson and uropod.

Banner at three different times. Types to be deposited in the U. S. National Museum.

DESCRIPTION: Anterior portion of carapace almost truncate anterior to eyes, rostrum produced into very slight angle; in lateral view anterior margin depressed; orbital hoods low but slightly higher than median area of carapace; rostral carina short, low and rounded. Pterygostomial angle of carapace slightly projecting but rounded; cardiac notch present. Cornea of eyes visible under carapace in lateral view.

Second antennular article 0.8 as long as broad, 0.7 as long as visible portion of first and 0.8 as long as third article. Stylocerite slightly shorter than basal article, acute but with lateral spine poorly developed. Outer flagellum with secondary ramus consisting of two articles; both flagella only slightly longer than base.

Basicerite with superior tooth heavy but short, subacute; lateral tooth heavy, long and acute, reaching to end of second antennular article. Scaphocerite with heavy lateral spine reaching beyond end of antennular peduncle, 1.2 times as long as the narrow squamous portion. Carpocerite longer, slender, reaching considerably beyond end of scaphocerite.

Third maxillipeds of normal form, with inner face of terminal article bearing numerous bristles and movable spinules.

Merus of large cheliped triangular, with definite margins between the faces, outer face 2.3 times as long as broad; superior distal and inferior internal angles unarmed. Carpus expanded and short. Chela 2.4 times as long as broad, 3.3 times as long as fingers, rounded in side view, laterally slightly compressed; short, heavy, rounded tooth above dactylar articulation. Dactylus heavy, compressed, with distal margin strongly arcuate; dactylus with usual "plunger" and without adhesive plaques. Very light scattered setae on both fingers.

Small cheliped with merus as long as that of large chela, but more slender. Carpus hemispherical but with inferior projecting flange that covers base of chela. Chela as long as merus, 1.6 times as long as broad, with fingers occupying distal third. Dactylus of peculiar shape, rounded on superior surface and rounded distally, with tip bearing strong, acute tooth at about 90° to fixed finger. Fixed finger broadened to meet dactylus and with tip projecting as two rounded teeth which articulate with dactylar tooth.

Second legs with ischium and merus heavy; carpus of right leg with four articles (ratio 10:1.5:1.7:2.7), that of the left with five (ratio 10:1.2:1.5:1.5:2.7).

Ischium of third legs unarmed. Merus 3.0 times as long as broad, unarmed. Carpus 0.4 as long as merus, armed with heavy terminal tooth on superior margin and small movable terminal spine on inferior margin. Propodus heavy, 5 times as long as broad, 0.8 as long as merus, armed with six slight spines on inferior margin. Dactylus biunguiculate, superior spine heavy and curved, inferior spine shorter, heavy and at about 90° to inferior margin.

Abdomen very broad, shallow, pleura expanded and second pleura bearing deposit of fat. Pleopods long and broad.

Uropods of usual form, outer bearing single distal lateral spine. Telson 5 times as long as posterior margin is broad, base 3.3 times as broad as tip; inner pair of spines of tip as long as tip is broad; dorsal spines about 0.7 as long as inner distal spines, located at 0.3 and 0.6 of the length posterior from articulation.

Nine eggs, 0.73 × 1.13 mm. in diameter.

Branchial formula: 5–1–2.

Allotype not exhibiting sexual dimorphism in any character except abdomen, which is less expanded, with shorter pleura and pleopods.

DISCUSSION: This series of 15 specimens exhibits variation in a number of characteristics. In some the anterior carapace projects relatively further (Fig. 8*c*), the truncate portion is narrower in dorsal view and less depressed in lateral view, and the orbital projections and rostrum are more pronounced,

also the rostral carina is slightly higher but still neither strong nor sharp. In one specimen, the front of the carapace is straight, showing no vestige of either the orbital teeth or the rostrum. In general the larger specimens have the straighter front. The pterygostomial angle also varies in the amount of projection but in no case is it definitely angular.

In all specimens the eyes are fully concealed in dorsal view, but with part of the cornea visible in lateral view, as is shown in Figure 8*b*.

No great variation has been noted in the antennular peduncle. However, the superior tooth of the basicerite is stronger and more acute in some specimens and its tip may reach almost as far forward as does the stylocerite. In many the flattened portion of the scaphocerite is more reduced, and in several the lateral spine of the scaphocerite does not reach past the middle of the third antennular article. The carpocerite is always markedly longer than the antennular peduncle.

On the large cheliped the distal superior margin of the merus may project to form a slight, rounded tooth and the inferior external margin in some specimens projects slightly more than it does on the type. The tooth above the dactylar articulation may be either more or less well developed than on type. The small cheliped does not show marked variations.

All specimens except one had four articles to the carpus of the second legs, and that one, like the type, had five articles in the carpus of the one second leg remaining on the specimen.

The proportions of the telson varied somewhat, and the dorsal spinules varied from about half the length to much larger than those in the type; in one specimen the posterior pair reach almost to the tip of the telson.

In the ovigerous females the size of the eggs was relatively constant, depending upon their maturity, but the number varied from five to fifteen.

Although the number of articles of the carpus, the almost flatly truncate anterior margin of the carapace, and the exposure of the cornea of the eyes in lateral view is unlike any other species of the genus *Synalpheus*, this species has been placed in this genus for the following reasons: *1*, The anterior teeth of the carapace approaches this condition in some of the species of the genus, e.g., *S. tanneri* Coutière (1909: 77). *2*, The general form of the antennular and antennal peduncles of this species is definitely like other species of *Synalpheus*. *3*, The pterygostomial angle of this species at least approaches the usual form for the genus. *4*, The large and small chelae are like other species of the genus, both in general form and in the presence of the plunger on the dactylus of the large chela and in the absence of adhesive plaques on the propodus and dactylus. Moreover, the form of the small chela is almost identical to that of *S. pescadorensis* Coutière (1905: 887). *5*, The form of the third legs is similar to other species of the genus and the form of the telson is often found in the genus. *6*, The branchial formula is that of *Synalpheus*.

The essential differences, then, between this and other members of the genus are in the four articles to the carpus of the third legs—which is variable in this species and has been found to vary in other species of this genus (Coutière, 1909: 20; Banner, 1953: 29), and in the exposure of the eyes, which may be merely the result of the reduction of the anteriorly projecting portion of the carapace.

Within the genus this species appears to fall in the old "Biunguiculatus" group, now better called the Coutièrei group (Banner, 1953: 37). Within this group it is related to those with a subspatulate dactylus of the small cheliped, but it can easily be separated by the extreme reduction of the orbital teeth and rostrum, by the lateral exposure of the cornea, and by the condition of the carpus of the second legs.

The name does not refer to any "two-faced" condition but rather to variation in the num-

ber of secondary articles in the carpus of the second legs.

ALPHEUS Fabricius
Megacheles group

Alpheus tuthilli (Banner)

Fig. 9

Crangon tuthilli Banner, Pacific Sci. 7(1): 63, fig. 19, 1953.

LOCALITY: Banner, one specimen, Saipan.

DISCUSSION: This specimen, a 16 mm. female, agrees in all characteristics with the specimen described from Hawaii except that the orbital teeth and lateral spine of the basicerite are slightly longer when compared to the rostrum.

The specimen has intact the small chela which was lost in the type specimen. In it the merus is 3 times as long as broad and 0.5 as long as the entire chela; it bears no superior spines, but the inferior internal margin bears 14 short movable spines and terminates in a small acute tooth. The ischium bears 5 similar spines. The chela is about 5 times as long as broad (the palm proper twice as long as broad), with the fingers 0.55 as long as the chela. The fingers are long and thin, only slightly curved, and have crossing tips. The opposing faces of the fingers produced as cutting edges that are each flanked on the inner side by a regular row of short stiff setae. The chela bears only occasional long setae.

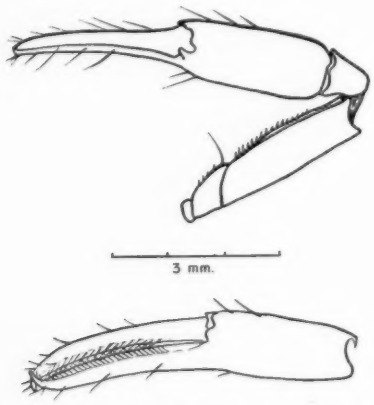

FIG. 9. *Alpheus tuthilli* (Banner). Small chela, female.

Alpheus species 1

LOCALITY: Banner, one specimen, Saipan.

DISCUSSION: This specimen without chelae belongs to a new species of the Megacheles group, wherein it is related to the *A. hailstonei* Coutière complex. Because the specimen is incomplete, the description and name will be deferred until a subsequent publication when a more complete specimen will be described.

Alpheus oahuensis (Banner)

Crangon oahuensis Banner, Pacific Sci. 7(1): 64, fig. 20, 1953.

LOCALITY: Banner, 2 specimens in one collection, Saipan.

DISCUSSION: These two specimens, a male and a female, differ in only two ways from the type described from shallow water in Hawaii. The lateral spine of the basicerite is longer and more acute, and the dactylus of the large chela, instead of being thin and crested in the middle and bulbous on the end, is relatively thicker in the middle and not distally expanded. The latter difference may be of significance, but inasmuch as the specimens are otherwise so similar, even to the opposing ridges of the fingers of the small chela, the specimens are assigned to this species.

Alpheus collumianus Stimpson

Alpheus collumianus Stimpson, Acad. Nat. Sci. Phila., Proc., 12: 30, 1860.

Alpheus collumianus probabilis subsp. nov.
Fig. 10

Three variants of this species occur in the present collections and because of the constancy of the differences exhibited are described as subspecies.

TYPES: Holotype, an ovigerous female 15

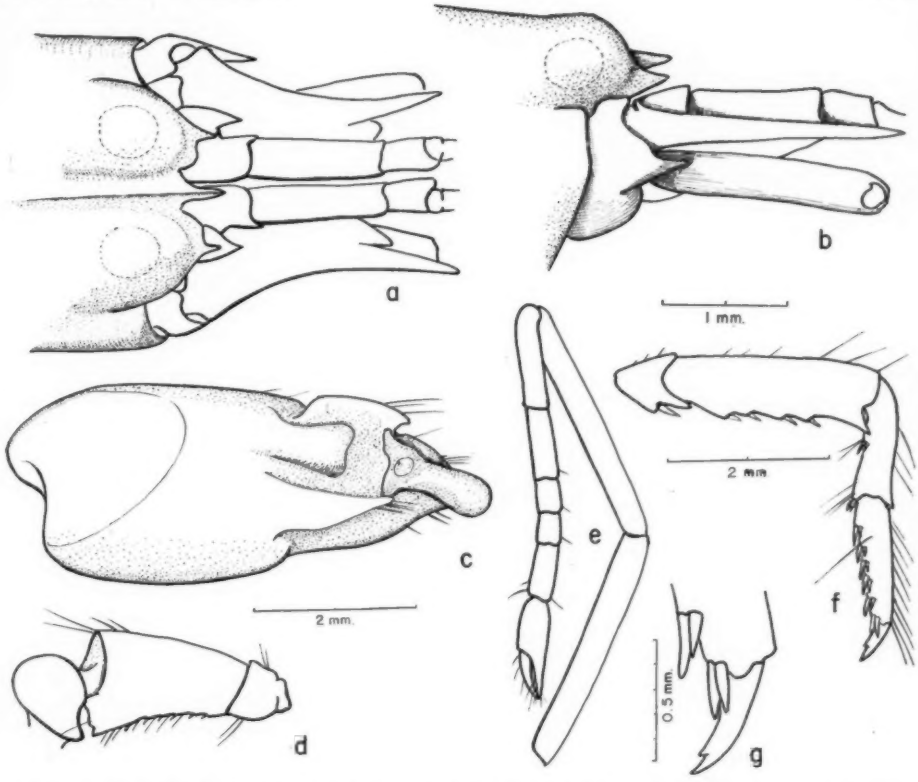

FIG. 10. *Alpheus collumianus probabilis* subsp. nov. *a*, *b*, Anterior region, dorsal and lateral aspects; *c*, large chela; *d*, large cheliped, merus; *e*, second leg; *f*, third leg; *g*, third leg, dactylus.

mm. long, collected by Preston E. Cloud, Jr., from Loc. C-7a, 13 May 1949. Paratypes: 1 specimen each from Cloud's localities A-7 and C-7a (10 April 1949). All types to be deposited in the U. S. National Museum.

DESCRIPTION: Rostrum acute, short, reaching 0.7 of visible portion of first antennular article, about twice as long as broad at base; depressed in lateral view so that tip is only slightly higher than orbital teeth. Rostral carina strong, narrowly rounded, extending posteriorly to orbital hoods, but lower than orbital hoods in lateral view. Orbital hoods inflated, rounded, and bearing short acute orbital teeth. Margin of carapace between orbital teeth and rostral base dorsoventrally flattened and expanded to form extended area in front of anteromedial portion of orbital hoods, base of rostrum demarked from this area by deep rounded indentations. Orbitorostral grooves deep but rounded, extending to posterior portion of orbital hoods.

Antennules with second article about twice as long as first and three times as long as third article, four times as long as broad. Stylocerite with well-developed spine reaching almost to end of first antennular article. Scaphocerite longer than antennular peduncle, laterally strongly concave, squamous portion reduced, reaching only to end of second antennular article. Carpocerite as long as antennular peduncle. Basicerite with strong lateral spine, tip reaching beyond end of first antennular article.

Large chela heavy, compressed, 2.4 times as long as broad, with dactylus slightly over 0.2 as long as the entire chela. Superior crest distal to transverse groove strong, narrow, ending in a strong tooth, proximal to transverse groove indistinct. Plaque crest heavy and rounded; superior and palmar grooves deep and distinct on distal third of face of palm. Inferior depression deep and sharply delimited; shoulder rounded. (For explanation of terms see Banner, 1953, fig. 17*e*.) Chela bearing scattered setae. Carpus of usual form. Merus 0.3 as long as chela, 1.4 times as long as internal face is broad at point of maximum width; inferior internal margin bearing six short strong spines and terminating distally in strong acute tooth.

Small chela lacking in all specimens.

Carpal articles of second leg with ratio: 10:8:4:4:6.

Third legs with ischium bearing strong movable spine; merus 3.3 times as long as broad, with inferior margin bearing four strong spines and terminating distally in strong acute tooth; carpus about 0.5 as long as merus, bearing pair of short spines on middle of inferior margin and another pair on inferior distal angle; propodus 0.7 as long as merus, bearing six pairs of short strong spines on inferior margin (including the terminal spines); dactylus biunguiculate, with inferior unguis about 0.3 as long as and smaller at base than distal unguis. Appendage bearing scattered setae.

Telson 2.0 times as broad at base as at tip, 3.3 times as long as tip is broad, with lateral margins almost straight and anterior pair of dorsal spines located at half distance from base to tip.

DISCUSSION: See under *A. collumianus inermis*, below.

A. collumianus medius subsp. nov.
Fig. 11

Crangon collumiana Banner, 1953, Pacific Sci. 7(1): 67, fig. 21.

TYPES: Holotype, a 19 mm. male, collected by A. H. Banner. Paratypes: Banner, 7 specimens from 4 collections. Cloud, 1 specimen at A-7, 3 at D-6, 1 at E-8, 8 at Loc. 6, 1 at Loc. 8.

DESCRIPTION: Rostrum acute, short, reaching half the length of visible portion of first antennular article, about as long as broad at base, only slightly depressed in lateral view. Rostral carina high but broadly rounded, reaching posteriorly to middle of orbital hoods, only slightly lower than orbital hoods in lateral view. Orbital hoods inflated, rounded, and bearing orbital teeth somewhat shorter than rostrum. Margin of carapace between orbital teeth and rostral base dorsoventrally flattened and expanded; base of rostrum demarked from this area by prominent but shallow indentation. Orbitorostral grooves anteriorly deep but disappearing at level of posterior portion of eyes.

Antennular peduncle with second article about 1.5 times as long as first article, 2.0 times as long as third, and 3 times as long as broad, otherwise similar to *A. collumianus probabilis*. Stylocerite also similar, but with spine less pronounced. Basicerite, carpocerite, and scaphocerite as described for *A. c. probabilis*.

Large chela as described for *A. c. probabilis*. Merus 0.2 as long as chela, 1.3 times as long as internal face is broad, inferior internal margin bearing only setae, and terminating in a strong but rounded tooth.

Small chela of male 0.7 as long as large chela, 3.0 times as long as broad, with the curved heavy fingers occupying 0.55 length of chela and somewhat expanded laterally; superior crest present and terminating distally in strong tooth, proximally at transverse groove; palmar crest and associated grooves poorly demarked; shoulder rounded. Carpus with short blunt tooth projecting over base of palm. Merus almost half as long as chela, 2.2 times as long as outer face is broad; inferior internal margin armed only with light setae and terminating in a low rounded lobe. Small chela of female very similar to that of

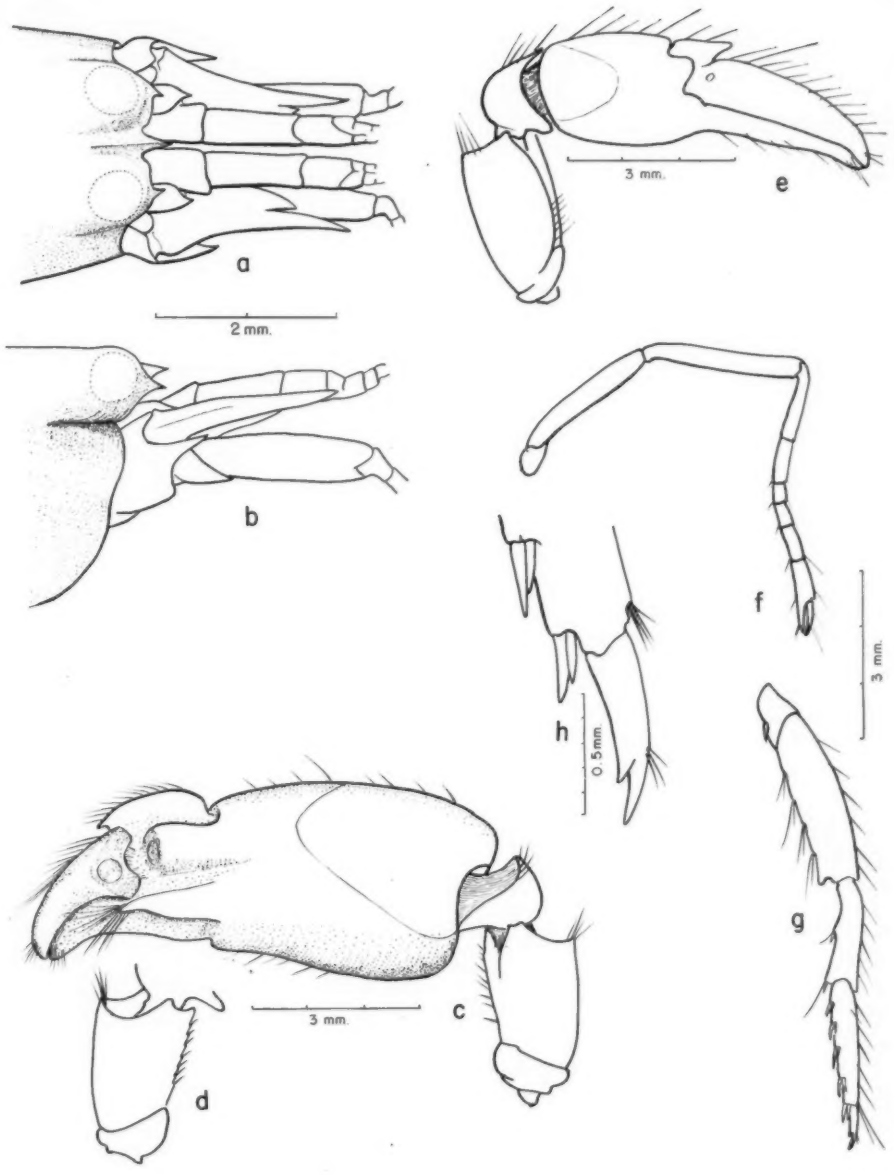

FIG. 11. *Alpheus collumianus medius* subsp. nov. *a*, *b*, Anterior region, dorsal and lateral aspects; *c*, large cheliped; *d*, large cheliped, merus, medial side; *e*, small cheliped; *f*, second leg; *g*, third leg; *h*, third leg, dactylus.

male, except somewhat smaller in proportion to large chela, with sculpturing of palm proximal to dactylar articulation less pronounced and dactylus without basal expansion, instead rounded.

Carpal articles of second legs with ratio: 10:8:3:4:5.

Third legs similar to *A. c. probabilis* except that merus is 3.6 times as long as broad, bears setae instead of movable spines on inferior margin, and margin terminates in rounded tooth; distal articles are correspondingly more slender and spines slightly smaller; lower unguis of dactylus slightly larger.

Telson 2.0 times as broad at base as at tip, 2.8 times as long as broad at tip, with anterior pair of dorsal spines slightly anterior to middle.

DISCUSSION: See under *A. collumianus inermis*, below.

A. collumianus inermis subsp. nov.
Fig. 12

TYPES: Holotype, a male 16 mm. long, collected by Preston E. Cloud, Jr. *et al.* from locality D-7. Paratypes: Cloud, 1 specimen at Loc. D-6, 2 specimens from Loc. D-7. Types to be deposited in the U. S. National Museum.

DESCRIPTION: Rostrum short, acute, reaching a little past middle of visible portion of the first antennular article, about as long as broad at the base, tip depressed in lateral view, no higher than front of orbital hoods. Rostral carina only slightly lower than orbital hoods, depressed towards tip, rounded and terminating before middle of eyes. Orbital hoods inflated, rounded, not bearing any teeth in type, but in other specimens bearing very slight acute teeth. Margin of carapace between orbital hoods and rostral base flattened but not extended; base of rostrum demarked by only very slight broadly rounded indentation. Orbitorostral grooves rather shallow and rounded.

Antennules with second article about 2.0 times as long as first and third articles, 2.5 times as long as broad. Spine of stylocerite much reduced. Carpocerite and scaphocerite as in *A. collumianus probabilis;* lateral margin of basicerite projecting almost at approximately 90°.

Large chela 2.5 times as long as broad, fingers occupying 0.25 total length; otherwise like *A. c. probabilis*. Merus 0.27 as long as chela, 1.8 times as long as broad, with inferior internal margin armed with setae and terminating in small rounded shoulder.

Small chela (loose in vial, either from type or from 16 mm. female) almost 0.6 as long as large chela, 3.4 times as long as broad, with fingers occupying 0.4 entire length. Sculpturing on palm not marked, but superior crest strong distally and terminating in strong acute tooth. Merus 0.6 as long as chela, 2.3 times as long as broad, with inferior internal margin unarmed.

Carpal articles of second legs with ratio: 10:9:4:4:7.

Third legs with ischium bearing strong spine; merus 3.7 times as long as broad, inferior margin unarmed except for rounded tooth distally; carpus and propodus similar to *A. c. probabilis* except carpus bears neither middle nor terminal spines, and propodal spines are smaller; dactylus with inferior unguis strongly reduced.

Telson similar in form to *A. c. probabilis*, but 2.5 times as broad anteriorly as posteriorly, 3.5 times as long as posterior margin is broad, and with anterior pair of dorsal spinules located 0.4 of length posterior to articulation.

DISCUSSION: The three groups of specimens described above as three subspecies are obviously related. When the inherent minor individual variations are allowed for, they are similar in form of the orbital hoods proper, the antennules and antennae (save for the basicerite and the stylocerite in the last subspecies), in the form of the large chela, in the ratios of the carpal articles of the second legs, in the spiny propodi and biunguiculate dactyli of the third legs, and in the general form of the telsons.

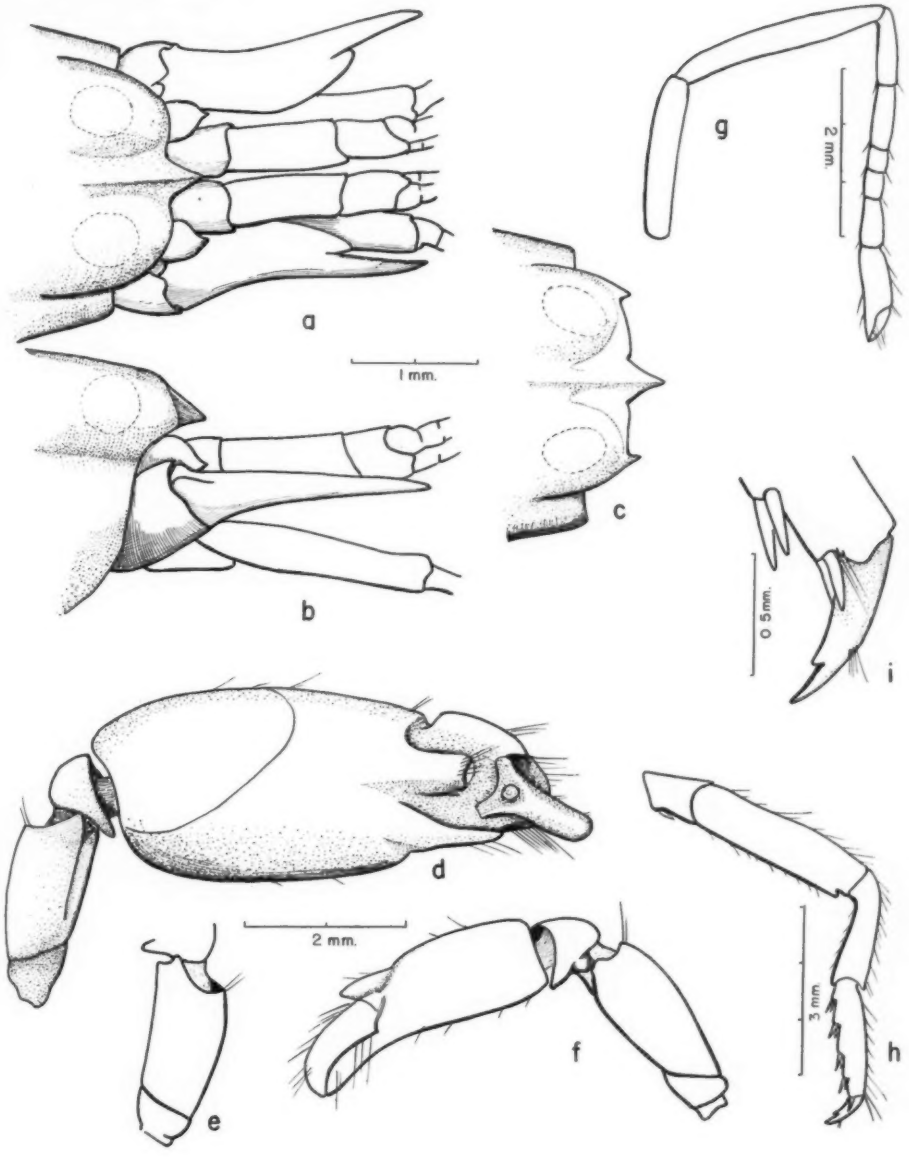

FIG. 12. *Alpheus collumianus inermis* subsp. nov. *a*, *b*, Anterior region, dorsal and lateral aspects (type); *c*, anterior region (paratype); *d*, large cheliped; *e*, large cheliped, merus, medial aspect; *f*, small cheliped; *g*, second leg; *h*, third leg; *i*, third leg, dactylus.

They differ, however, in the following points:

1. The orbitorostral front. This can best be understood by comparing Figures 10*a*, 11*a*, 12*a*. It should be noted that in three of the four specimens of *A. c. inermis* there are very short orbital teeth, and that *A. c. medius* can be considered a very logical intermediate between the other forms.

2. The stylocerite. Again *A. c. medius* is intermediate between the strong spine of *A. c. probabilis* and the very small spine of *A. c. inermis*.

3. The basicerite. In both *A. c. probabilis* and *A. c. medius* the lateral angle is produced into a strong tooth whereas in *A. c. inermis* it varies from a rounded right angle to a slightly acute angle.

4. The merus of the third legs. *A. c. probabilis* bears four spines and a very strong terminal tooth, *A. c. medius* bears strong bristles corresponding to the spines, and rounded and weaker tooth, and *A. c. inermis* bears scattered weak bristles and a small rounded tooth.

5. The carpus of the third legs. *A. c. probabilis* and *A. c. medius* bear both middle and distal inferior spines (although *A. c. medius* may often lack the middle spines), and *A. c. inermis* bears no spines.

Differences in the proportions of the antennules, antennae, large and small chelae, second and third legs, and telsons probably would not be found to be very significant if larger populations were measured.

In view of the striking similarities yet pronounced differences, it was difficult to decide whether these should be described as separate species or subspecies. There is no way of determining from the specimens and data at hand whether they represent separate ecological groups that would interbreed freely if mixed, or separate co-mingling species that cannot or will not interbreed; however, there is some indication from the collection data that they are separated ecologically, and their similarities lead me to believe they are merely subspecies.

Without Stimpson's type for comparison —and as far as I have been able to determine, Stimpson's type for this species has been lost like his types for the other alpheids he described—it is difficult to decide which of these, if any, is similar to the specimen for which he gave such a short diagnosis. However, he did state about the third legs, "mero lato, inferne spinuloso et apicem unidentato," which could be applied only to the form described above as *A. collumianus probabilis*. Inasmuch as the original type came from the Bonin Islands, only about 800 miles to the north of Saipan, it is probable that this is identical with the typical subspecies, but because of the distance and the lack of specimens from the Bonins it is inadvisable to assume this to be exactly the same form as would be found there. According to the Copenhagen decisions (paragraph 35, sect. 7) ". . . the neotype . . . [should come] from as near as possible to that locality [from which the holotype was obtained. . . .]," so the description of this subspecies as *A. collumianus* collumianus—which would be essentially the establishment of a neotype—would be of questionable legality.

Without re-examining the specimens it is impossible to be certain to which subspecies the specimens reported by Coutière, de Man and others belong. However, as they did not remark on the differences, it is likely they were *A. collumianus probabilis* (or *A. c. collumianus*). The specimens reported from the Hawaiian Islands by Edmondson and myself definitely belong to *A. c. medius*.

Alpheus deuteropus Hilgendorf

Alpheus deuteropus Hilgendorf, K. Akad. Wiss. Berlin, Monatsber. 1878: 834.

Crangon deutropus Banner, Pacific Sci. 7(1): 70, fig. 22, 1953.

LOCALITIES: Banner, 1 specimen; Cloud, Loc. 8, 4 specimens. These specimens agree

almost perfectly with the specimens from Hawaii if the range of variation there is considered.

Macrochirus group

Alpheus gracilis var. **simplex** (Banner)

Alpheus gracilis Heller, K. Akad. Wiss. Wien, Sitzungber. 44: 271, Taf. 3, figs. 19–20, 1861.

Crangon gracilis var. *simplex*, Banner, Pacific Sci. 7(1): 75, fig. 25, 1953.

LOCALITY: Banner, 4 specimens from one collection, Saipan.

DISCUSSION: These four specimens agree well with the form described from Hawaii with two exceptions: the dorsal carina, which is lacking in the Hawaiian form and present between the orbital hoods in the typical subspecies, is present but only as a low and obtusely angular ridge in these specimens (it is not delimited, however, by the deep orbitorostral furrows which are found in the typical form); the inferior convexity of the dactylus of the third legs of the Hawaiian form is here developed as a low but flattened protuberance with proximally and distally rounded margins.

Three of the specimens have black spines on the uropods; in the fourth the spines are dark brown.

Alpheus edmondsoni (Banner)

Crangon edmondsoni Banner, Pacific Sci. 7(1): 78, fig. 26, 1953.

LOCALITY: Banner, 2 specimens from one collection, Saipan.

These specimens fall well within the range of variation noted in Hawaii.

Alpheus ventrosus Milne-Edwards

Alpheus ventrosus Milne-Edwards, Histoire Naturelle des Crustaces, 2: 352, 1837.

Alpheus laevis Randall, Acad. Nat. Sci. Phila., Jour. 8(1): 141, 1839.

Alpheus obesomanus Boone, Vanderbilt Mar. Mus., Bul. 6: 135, 1935 [partim].

Crangon ventrosa Banner, Pacific Sci. 7(1): 84, fig. 28, 1953.

LOCALITIES: Banner, 2 specimens in one collection; Cloud, Locs. 6, 8, 9, one specimen each.

DISCUSSION: Two variations are noted in these specimens. First, in several of the smaller specimens, especially in a 15 mm. ovigerous female from Cloud's locality 9, the interorbital continuation of the rostrum is high and narrow, almost a rounded carina, instead of flat and broad across the top. In this respect these specimens resemble *A. latipes* (Banner) more closely than they do *A. ventrosus*.

In the two specimens of my own collection, the external spines of the uropods in the 16 mm. female are light brown, and in the accompanying 15 mm. male they are dark brown, almost black. Such dark spines are found in the Macrochirus group and this is often used as a specific characteristic but it has not been remarked upon before in this species.

Alpheus nanus (Banner)

Crangon nanus Banner, Pacific Sci. 7(1): 90, figs. 30, 31, 1953.

LOCALITIES: Banner, 8 specimens in 3 collections; Cloud, locality D-6, 2 specimens.

DISCUSSION: These specimens agree perfectly with those from Hawaii except that about half of these bear up to six weak spinules or short bristles on the inferior internal margins of the meri of the large and small chelipeds.

Alpheus paragracilis (Coutière)

Alpheus paragracilis Coutière, Paris Mus. d'Hist. Nat., Bul. 3(7): 304, 1897*b*.

Crangon paragracilis Banner, Pacific Sci. 7(1): 96, fig. 33, 1953.

LOCALITY: Cloud, Loc. 6, 2 specimens.

These specimens agree well with those described from Hawaii.

Obesomanus subgroup

Alpheus microstylus (Bate)

Betaeus microstylus Bate, Challenger Repts. 24: 566, pl. 101, fig. 6, 1888.

Alpheus obesomanus de Man, Arch. Naturg. 53: 520, 1888; Abhandl. Senckenb. Naturf. Gesells. 25: 867–869, 1902.

Alpheus malleodigitus Coutière, Les Alpheidae, p. 223, 316 (figs. 270–272, 400) 1899 [nec *A. malleodigitus* (Bate)].

Alpheus microstylus Coutière, Fauna and Geog. Mald. and Laccad. 2: 884, pl. 76, fig. 23, 1905.

LOCALITIES: Banner, 5 specimens in one collection; Cloud, 15 specimens at locality A-5, 4 at FX.

DISCUSSION: The few specimens of this species exhibit some interesting variations. The scale of the antenna is usually similar to that depicted by Coutière (1905) but in several specimens it is shortened, and in one the squamous portion is so reduced that it does not reach to the end of the second antennular article. The merus of the large chela usually bears an obtuse tooth distally on the inner inferior margin, but in some specimens this tooth is acute, and in one small specimen it is reduced to a slight rounded eminence. The ratio of the first two articles of the carpus of the second legs varies from slightly less than 1:3 to more than 1:4. Finally, the propodus of the third legs is armed with five to seven spines instead of only five, as described by Coutière.

Alpheus lutini Coutière

Alpheus lutini Coutière, Fauna and Geog. Mald. and Laccad., 2: 885, pl. 76, fig. 24, 1905; de Man 1911, Siboga Exped. 39a[1]: 346, pl. 14, fig. 69 [additional description].

LOCALITIES: Banner, 65 specimens in 8 collections; Cloud, 2 specimens at localities A-7, 3 at C-1, 1 at C-7a (13 May 1949), 6 at D-5.

DISCUSSION: This species is more variable than has been indicated previously, and shows variation in most of the structures commonly measured. For example, the squamous portion of the scaphocerite, while always poorly developed, may be twice as large in some specimens as in others; the lateral spine of the scaphocerite may equal the antennular peduncle in length, or it may reach only slightly beyond the end of the second antennular article (in one specimen the spine of the left scale reached to the end of the second antennular article, whereas the right reached only to the middle of the same article). Coutière stated that the second legs were 3 times as long as the carapace, whereas in these specimens they vary from about 2 times to more than 3.5 times as long. Similar variations in proportions occur in the chelae and in the third legs.

Except for these variations these specimens agree very well with Coutière's description. At times however, this variation caused difficulty in the use of de Man's key (1911), for while de Man stated that the small chela was less than 3.0 times the length of the fingers (Coutière's ratio was 2.5), it was actually found to be as much as 3.2 times this length.

Alpheus phrygianus Coutière

Alpheus phrygianus Coutière, Fauna and Geog. Mald. and Laccad. 2: 886, pl. 77, fig. 25, 1905.

LOCALITIES: Banner, 2 specimens in one collection; Cloud, 3 specimens at locality A-5, 2 at A-7, 2 at C-1, 3 and 4 at C-7 on 4 April and 13 May 1949, respectively, 2 at D-5, 2 at D-8, 2 at E-7.

DISCUSSION: This species is abundant in the Saipan collections, but few of the specimens are intact, probably in part because most of the specimens died with the long thoracic legs outspread.

In general the specimens agree with Coutière's description of specimens from the Indian Ocean; however, far greater variation is seen in these specimens than was noted by Coutière for his four specimens.

In the younger specimens (less than 10 mm. long) the antennular peduncle is shorter, especially the second article. In the antenna, the spine on the scaphocerite varies from about two-thirds the length of the second antennular article (on an 8 mm. specimen) to less than one-third its length on mature specimens; the squamous portion in some specimens is as depicted by Coutière, arising abruptly at slightly more than half of the length of the outer spine, but in others it tapers gradually to near the tip of the spine, with most of the specimens intermediate in condition; in most the squamous portion is without setae as described by Coutière, but in a few there are some short feeble bristles along its margin; finally, the antennal peduncle varies from reaching the tip of the second antennular article to reaching only two-thirds its length. The large chela does not exhibit any marked variation. In the small chela most of the specimens have fingers more nearly 1.3 times the length of the palm than 1.0 as in the type specimen. Coutière remarked that the second leg varies from 2.2 to 4 times the length of the carapace; in a few of these specimens the second legs are almost 5 times the length of the carapace. On the third leg the spine on the inferior distal margin of the merus usually is small and subacute like that depicted by Coutière, but in several it is strong and acute, and in one it is reduced to a rounded protuberance; on the propodus there are usually seven instead of five spines. The telson usually approaches the proportions given by Coutière, but in some the tip is relatively broader so the length is only 3.2 times the breadth of the tip instead of 4.5. These variations do not appear to be consistent enough to be of taxonomic importance.

Alpheus perplexus sp. nov.
Fig. 13

(?) *Alpheus* species, de Man, Siboga Exped. 39a[1] (2): 349, pl. 15, fig. 71, 1911.

TYPES: Holotype, an 18.8 mm. male collected by Preston E. Cloud, Jr., from locality A-7; allotype, an ovigerous female 20.4 mm. long, same location. Types to be deposited in the U. S. National Museum.

DESCRIPTION: Front of carapace straight (in type) to concave (in allotype); orbital hoods somewhat inflated and rounded; interorbital carina slight and rounded, not reaching to anterior margin of carapace or posterior to end of orbital hoods.

Second antennular article 2.1 times as long as visible portion of first, 2.3 times as long as third, and 3.3 times as long as broad. Stylocerite rounded. Scaphocerite reaching slightly beyond end of second antennular article; carpocerite reaching almost to end of third antennular article; basicerite unarmed.

Large chela of type specimen heavy, 2.8 times as long as broad, flattened, and with fingers occupying 0.2 of entire length. Only distal third of chela sculptured; superior crest interrupted by deep, abrupt transverse groove, distal to transverse groove crest thin, high, terminating in a rounded shoulder. Plaque crest heavy, rounded, separated from superior and inferior crest by deep grooves. Inferior crest pronounced, distally high and thin, terminating in a rounded shoulder flanking dactylus. Inferior shoulder rounded. Fixed finger very short, distally notched to receive dactylus. Dactylus closing almost across end of palm, heavy, rounded, nearly hammer-shape. Merus 0.3 as long as chela, 3.1 times as long as broad, without teeth or spines, with inferior external margin rounded.

Large chela of female of similar armature, but relatively much smaller than that of male, 3.9 times as long as broad.

Small chela lacking in male; in female chela 4.5 times as long as broad, with heavy fingers occupying distal 0.3; small tooth projects superior to articulation at approximately 90°.

Second legs long, strong, with merus about 0.7 as long as large chela in type. Carpal articles with ratio: 10:11:3:4:5.

Third legs with ischium armed with rather weak spine; merus almost 4 times as long as

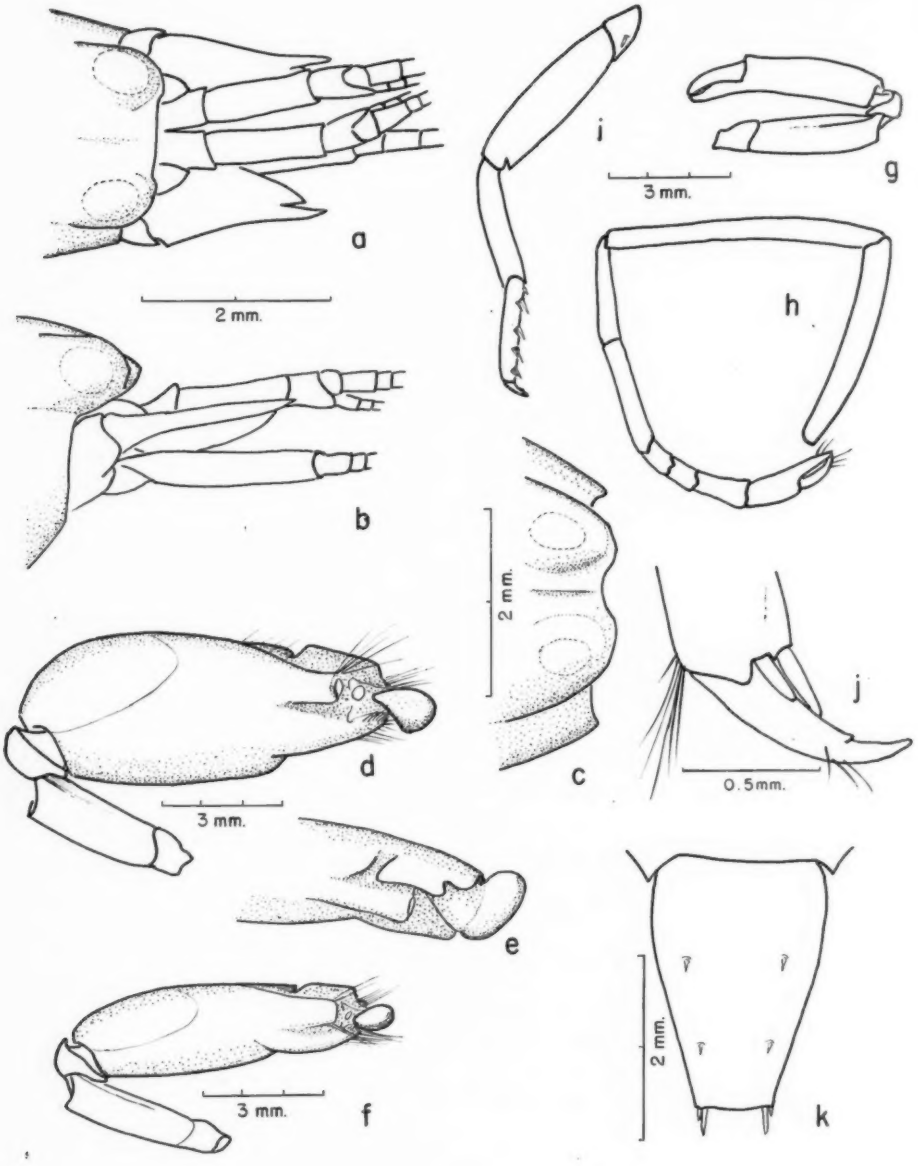

FIG. 13. *Alpheus perplexus* sp. nov. *a*, *b*, Anterior region, dorsal and lateral aspects, type specimen; *c*, anterior region, dorsal aspect, allotype (specimen asymmetrical); *d*, *e*, large cheliped, lateral and superior aspects, type specimen; *f*, large cheliped, allotype; *g*, small cheliped, allotype; *h*, second leg; *i*, third leg; *j*, third leg, dactylus; *k*, telson.

broad, armed with weak sub-acute tooth distally; carpus 0.7 as long as merus, unarmed except for two rounded projections distally; propodus 0.6 as long as merus, armed with one single and five pairs of spines on inferior margin; dactylus curved, with very slight secondary tooth (on female secondary tooth somewhat larger).

Telson 3.3 times as long as posterior margin is broad, 2.3 times as wide anteriorly as posteriorly; sides slightly rounded, both pairs of dorsal spinules small, anterior pair 0.4, posterior pair 0.7 length of telson posterior to articulation. Inner uropod with several weak spinules on outer distal margin.

DISCUSSION: This species is difficult to assign to an infrageneric group, for the anterior carapace and second legs are very much like those found in the Obesomanus group, but the large chela is more like those found in the Macrochirus group. The dactylus of the large chela, which should be hammer-shaped in the Obesomanus group, is intermediate between the form found in many species of the Megacheles and Macrochirus groups and those found in the Obesomanus group.

Only on the basis of the lack of a rostrum and of orbital teeth was this species assigned to this group. Within the group it is definitely separated from all other named species by the form of the large chela and by the fact that the dactyli of the third and fourth legs carry a small secondary unguis.

The species appears to be similar to the specimen that de Man briefly described but left unnamed because it lacked both of the chelae and the second legs. Between the two specimens there are differences in proportions of the antennules, antennae, third legs and telson, but these differences are slight and probably not significant. Also de Man's specimen had a slight rostrum with the interorbital carina reaching to its tip, while neither of these specimens show a trace of the rostrum, and the interorbital carina terminates posteriorly to the margin of the carapace. This too, in view of the fact that the two specimens available show some variation, and that marked variation has been reported for species showing a similar frontal region, may be without significance. The armature and general form of the 3rd legs are similar. (De Man described the stylocerite as acute, but figured it as similar to those of these specimens.)

The difference between the form of the large chela in the male and the female is interesting. While in most species the chela of the female is considerably smaller than that of the male, it is seldom that the proportions are so pronouncedly different. It is possible, of course, that these specimens represent two species, but as they are similar in other characteristics, as they bear similar sculpturing on the large chela, and as they were collected together at the same station, it seems unlikely that they are other than a single dimorphic species.

Alpheus chamorro sp. nov.
Fig. 14

TYPE: Holotype, a 7.5 mm. male collected by A. H. Banner. Specimen to be deposited in U. S. National Museum.

DESCRIPTION: Anterior margin of carapace projecting beyond orbital hoods as narrow, somewhat flattened shelf; rostrum small, tip rounded; rostral carina low but sharp, extending from behind orbital hoods to tip of rostrum. Orbital hoods inflated, rounded, and anteriorly set off by medial flat orbitocarinal area.

Second antennular article 1.7 times as long as broad; first and third articles subequal in length and 0.7 as long as second article; stylocerite short, anteriorly acute. Basicerite unarmed. Scaphocerite with heavy lateral spine reaching to end of third antennular article, with reduced squamous portion reaching to end of second article. Carpocerite longer than antennular peduncle.

Large chela round, inflated, 2.6 times as long as broad and 2.2 times as long as high (*i.e.*, when the dactylus is seen in profile), fingers occupying the distal 0.25. In profile,

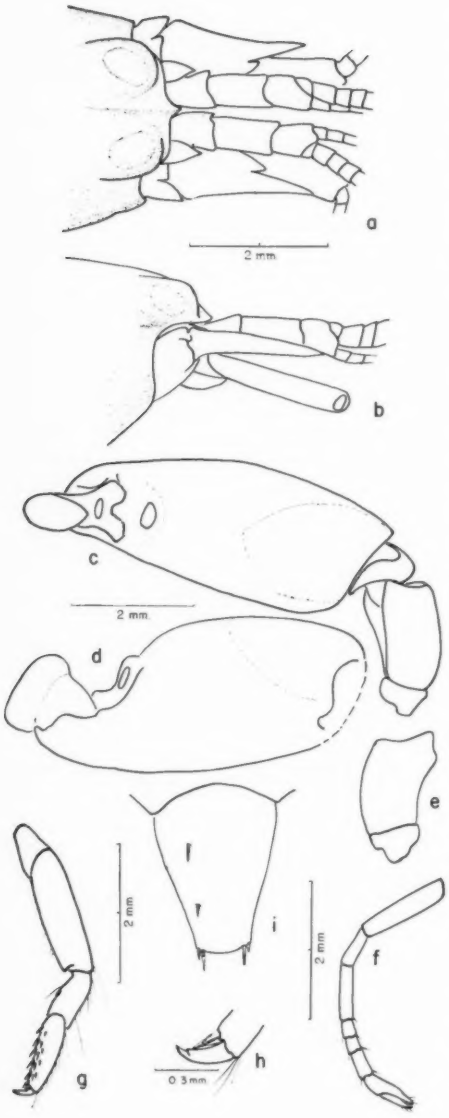

FIG. 14. *Alpheus chamorro* sp. nov. *a*, *b*, Anterior region, dorsal and lateral aspects; *c*, *d*, large cheliped, lateral and inferior aspects; *e*, merus, large cheliped, medial aspect; *f*, second leg; *g*, third leg; *h*, dactylus, third leg; *i*, telson (dorsal spinules lacking in specimen).

chela slopes abruptly toward articulation of dactylus; palmar adhesive plaque borne upon rounded eminence protruding from slope. Fixed finger short, cleft to accommodate dactylus. Dactylus short, heavy, but not as strongly hammer-shaped as in some other members of the group. Merus short, heavy, 0.4 as long as chela, outer face 1.4 times as long as broad; inferior internal margin bearing heavy rounded protuberance but otherwise unarmed.

Small chela lacking in specimen.

Carpal articles of second legs with ratio: 10:14.7:4.7:4.0:7.3.

Ischium of third legs unarmed. Merus 3.3 times as long as broad, bearing rounded tooth of moderate development on inferior distal margin. Carpus heavy, 1.6 times as long as broad, 0.35 as long as merus, armed with short heavy spine in middle of inferior margin and distally with two heavy subacute projections. Propodus correspondingly heavy, 0.6 as long as merus, armed with six pairs of spines along inferior and inferodistal margins, with scattered smaller spines adjacent. Dactylus strongly curved bearing small secondary unguis that is difficult to discern.

Uropods of usual form. Telson short, broad and abruptly tapering, 3.1 times as long as distal margin is broad, 2.3 times as wide proximally as distally; dorsal spinules well developed on left side only, anterior spinule 0.3, posterior 0.7 of length posterior to articulation.

DISCUSSION: While the general form, even to the shape of the anterior carapace and the secondary unguis on the dactylus of the third legs is very reminiscent of *A. paralcyone* (Coutière) of the Crinitus subgroup, the hammer-shaped dactylus of the chela of this species shows that it definitely belongs to the Obesomanus subgroup.

Unlike all species of the Obesomanus subgroup except *A. perplexus* Banner (above) and, if distinct, *A.* species de Man (1911: 349), *A. chamorro* has a biunguiculate dactylus on the third legs.

This species can be distinguished easily from *A. perplexus* by the form of the large chela, which is rounded in this species but bears deep sculpturing in *A. perplexus*.

The comparison of this species, *A. perplexus* and de Man's *A.* species shows the difficulty of trying to identify an incomplete specimen, for although the chelae show that *chamorro* and *perplexus* are not even closely related, each is similar enough to de Man's description of his broken specimen to be confused with it. *A. chamorro* is quite like de Man's specimen in the configuration of the anterior carapace and the bases of the antennae and antennules, but dissimilar in the structure of the third legs; *A. perplexus* is less like de Man's specimen in the anterior carapace but more similar in the third legs. After careful consideration it appears that the legs are more constant in their character than the anterior carapace, so de Man's specimen has been assigned, but still with doubts, to *A. perplexus*.

It should also be noted that *A. chamorro* shows affinity to *A. bradypus* Coutière (1906: 891) in the Crinitus group. While there are specific characteristics adequate to separate them easily, such as the dactylus of the third legs and the slight proximal projection of the "head" of the dactylus of the large chela, in general configuration the two species are strikingly similar, even to the shape of the eminence that bears the palmar adhesive plaque and the rounded protuberance on the inferior internal margin of the large chela. While the two species may merely show convergent evolution, or may be closely related on the limits of their respective groups, this may also indicate that the groups were separated upon artificial criteria.

The specific name has reference to the Chamorro people, the original inhabitants of the Mariana Islands.

Alpheus species 2
Fig. 15

SPECIMEN: A 11.2 mm. female, nonovigerous, collected by A. H. Banner.

DESCRIPTION: Anterior carapace without trace of rostrum, rostral carina, or orbitorostral furrows but uniformly inflated and rounded over eyes.

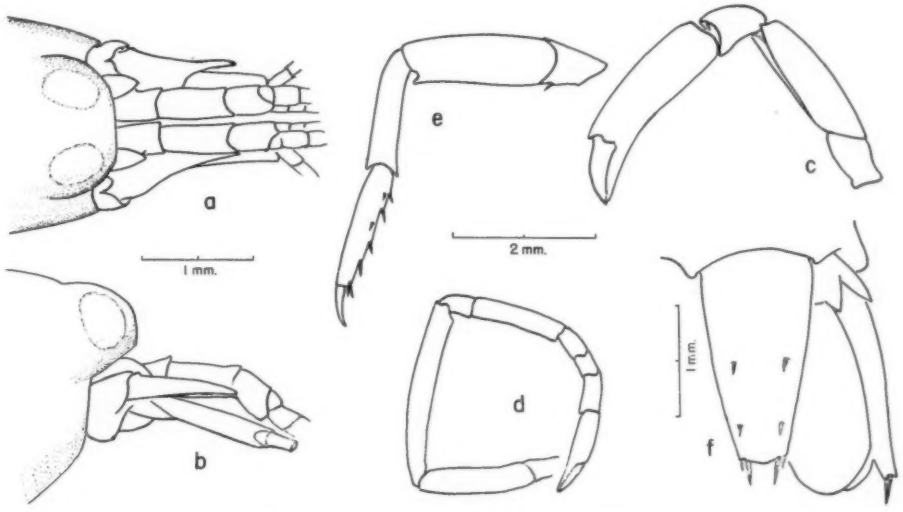

FIG. 15. *Alpheus* species 2. *a*, *b*, Anterior region, dorsal and lateral aspects; *c*, small cheliped; *d*, second leg; *e*, third leg; *f*, telson and uropods.

Antennular peduncle with second article 2.5 times as long as broad, 1.7 times as long as visible portion of first and third article which are subequal. Stylocerite without lateral spine, rounded, reaching half length of basal article. Upper flagellum slightly shorter than peduncle, lower shorter than upper. Basicerite unarmed. Lateral spine of scaphocerite reaching to end of second antennular article; flattened portion reduced, narrow, reaching only to first third of second antennular article. Carpocerite approximately as long as antennular peduncle. Flagellum of usual form.

Large chela lacking. Small chela rounded, regular, slightly curved toward fingers, 4.0 times as long as broad, with fingers occupying distal 0.3. Carpus somewhat elongate. Merus unarmed, outer face 3.6 times as long as broad, 0.7 as long as chela.

Carpal articles of second legs with ratio: 10:30:8:7:13.

Ischium of third legs bearing reduced spine. Merus 4.1 times as long as broad, distal inferior margin bearing tooth of moderate size. Carpus 0.66 as long as merus, distally produced into superior and inferior acute teeth of moderate size. Propodus 0.83 as long as merus, bearing eight spines irregularly placed on inferior and distal margins. Dactylus simple, curved, 0.26 as long as merus.

Telson 2.8 times as long as posterior margin is wide; anteriorly 1.5 times as wide as posteriorly; margins very slightly convex. Uropods of normal form; distal spine of outer uropod not black.

DISCUSSION: Without the large chela on this specimen, it is impossible to assign it even to group. The reduction of the orbital teeth and the reduction of the scaphocerite together with the armature of the third legs, would indicate that it may belong to the Obesomanus group, but, without knowing whether the dactylus of the large chela is hammer-shaped or not, it cannot be assigned for certain. Certainly the unique character of the front of the carapace does not show close relationship to any group or to any species of the genus *Alpheus* known to me.

The form of the rostral front appears to be similar to that described by Armstrong (1949: 12) as characteristic of his new genus, *Thunor*. However, on all other characteristics for this genus—absence of the cardiac notch on the carapace, the absence of anal tubercles, the absence of an articulation in the outer uropods (the ocular beak was not examined)—this species differs from *Thunor* and resembles *Alpheus*. In view of the wide variation in the rostral front found in *Alpheus* the one similarity was not considered to be of generic importance.

Because the specimen is imperfect it has been left unnamed.

Crinitus subgroup

Alpheus cloudi sp. nov.
Fig. 16

TYPE: Holotype, a unique ovigerous female 17.6 mm. long, collected by Preston E. Cloud, Jr., at locality D-5. Specimen to be deposited in the U. S. National Museum.

DESCRIPTION: Body form short, heavy. Anterior portion of carapace depressed when seen in lateral view. Orbital hoods inflated, rounded, demarked from anteromedial portion of carapace and overhanging anterolateral portion. Anteromedial portion of carapace broad, flat, projecting, margins almost straight; rostrum proper poorly demarked from adjacent portions of carapace, short, broad, with tip reaching beyond middle of visible portion of first antennular article. Rostral carina low but sharp reaching posteriorly from tip of rostrum to slightly behind orbital hoods. Eyes small, not filling orbital hoods.

Second antennular article about 2 times as long as broad, 1.3 times as long as visible portion of basal article, 2.4 times as long as distal article. Stylocerite short, heavy, with acute tip reaching almost to end of first antennular article. Basicerite bearing small spine. Scaphocerite reaching to near end of

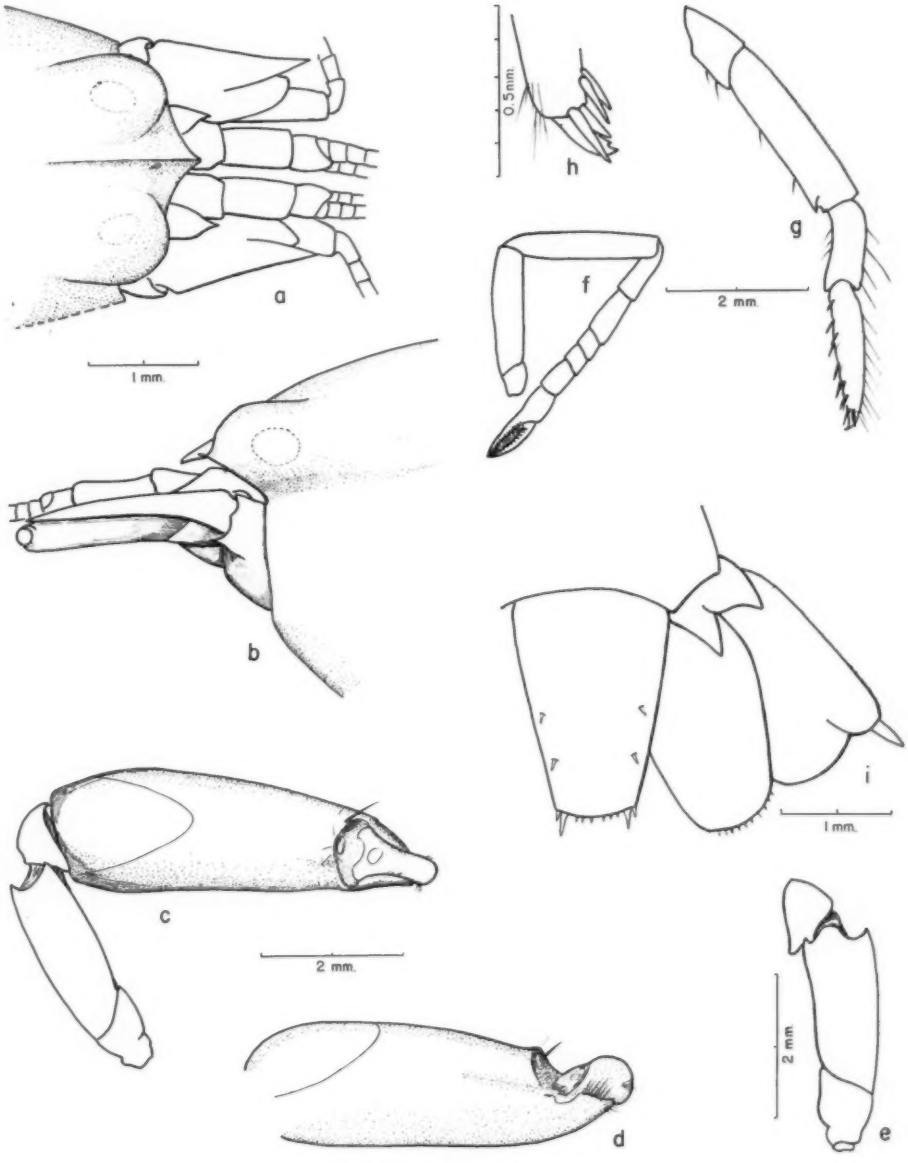

FIG. 16. *Alpheus cloudi* sp. nov. *a*, Anterior region, dorsal aspect (right margin distorted in specimen but reconstructed in drawing); *b*, same, lateral aspect; *c*, large cheliped, lateral aspect; *d*, large chela, inferior aspect; *e*, large cheliped, merus, medial aspect; *f*, second leg; *g*, third leg; *h*, third leg, dactylus, posterior or lateral aspect; *i*, telson and uropod.

antennular peduncle, squamous portion reaching to end of second antennular article; outer margin almost straight. Carpocerite reaching slightly beyond end of antennular peduncle and scaphocerite.

Large chela subcylindrical, as broad as high, slightly tapering distally, 3.1 times as long as broad. Palm below and immediately proximal to adhesive plaque with slight longitudinal depression. Dactylus 0.23 as long as entire chela, somewhat crested, rounded. Chela almost devoid of setae. Merus 2.6 times as long as broad, almost 0.5 as long as chela; superior margin distally projecting as small rounded tooth; inferior internal margin terminating distally in small acute tooth that is difficult to discern.

Small chela lacking.

Second legs relatively short, heavy. Carpal articles with ratio: 10:9:3.5:3.5:5.5; first article 3 times as long as broad. Chela 1.5 times as long as first carpal article, palm occupying slightly over 0.3 the entire length; fingers arched, tips crossing, bearing stiff combs of setae that cross.

Third legs heavy, ischium unarmed. Merus 4 times as long as broad, distal inferior margin armed with tooth of moderate development.

Carpus 0.38 as long as merus, both distal margins projecting as rounded teeth. Propodus 0.7 as long as merus, strongly tapering, distally only half as broad as proximally; inferior margin bearing 11 strong acute spines. Dactylus short, partially hidden, especially in anterior or median view, by propodal spines, some of which are equal in length to dactylus; dactylus heavy, curved, bearing slight biunguiculation that is difficult to discern both because of spines and normal rotation of dactylus.

Abdomen broad, rather soft. Sixth abdominal segment without spines or teeth. Telson 2.0 times as broad anteriorly as posteriorly, 3.4 times as long as broad posteriorly; sides straight, posterior margin slightly arcuate; anterior pair of dorsal spinules 0.5, posterior pair 0.8 of distance to tip from articulation; tip bearing about six very small spinules in addition to usual posterolateral spines. Uropods of usual form, inner bearing about 10 spinules along distolateral margin similar to those on tip of telson.

DISCUSSION: This species apparently belongs to the Crinitus subgroup in spite of the fact that the chela bears a short, shallow, longitudinal groove. Within the group it appears to be most closely related to the species *A. alcyone* de Man, *A. providencei* Coutière, *A. arethusa* de Man, and *A. paralcyone* Coutière. From *A. alcyone* it may be separated by the lack of spines on the merus of the third legs as well as other charactertics. It is separated from *A. arethusa* and *A. paralcyone* by a combination of characters, one of the more conspicuous being the lack of spines or teeth on the sixth abdominal segment. It appears to be somewhat related to *A. providencei*, especially in the frontal regions of the carapace, the antennular and antennal peduncles, the general form of the third leg and the trace of biunguiculation of its dactylus but it can easily be separated by the more elongate rostral triangle, the presence of a spine on the basicerite, the more elongate large chela, the armature of the merus of the cheliped, the shorter second article of the carpus of the second legs, the short dactylus of the third legs, and the form and armature of the uropods and telson.

The species was named in honor of Preston E. Cloud, Jr., U. S. Geological Survey, who collected this and many of the other specimens reported in this study.

Alpheus brevipes Stimpson

Alpheus brevipes Stimpson, Acad. Nat. Sci. Phila., Proc. 12: 30, 1860.

Crangon brevipes (Stimpson) Banner, Pacific Sci. 7(1): 103, figs. 35–37, 1953. [Neotype established.]

LOCALITIES: Banner, 2 specimens in 2 collections; Cloud, 8 specimens at Loc. D-8, 1 at Loc. 6.

DISCUSSION: These specimens, together

with the specimens from Arno, Onotoa, and Palmyra to be reported upon in later papers, parallel the variation already reported from Hawaii (Banner, 1953: 103). It should be noted under the variation of the frontal region of the carapace that only rarely were the "Orbital hoods acute in front, with their apices curved inward," a characteristic given by de Man in his key (1911: 315); instead the ridges of the orbital hoods were usually rounded, and often did not slope medially towards the ventral side.

Alpheus bucephalus Coutière

Alpheus bucephalus Coutière, Fauna and Geog. Mald. and Laccad. 2: 890, pl. 78, fig. 29, 1905.

LOCALITIES: Banner, 12 specimens in four collections; Cloud, 3 specimens at D-5, 3 at D-8, 1 at E-4, 1 at FX.

DISCUSSION: Several of the larger male specimens which otherwise agree with the characteristics of the species have broadened fingers on the small chelae, a trait that is not supposed to occur in this species. However, as the specimens are similar to *A. bucephalus* in all other characteristics, and as they were in a mixed collection with smaller specimens without the broadened finger, they have been assigned to this species. This peculiarity will be discussed in a future paper.

Alpheus bradypus Coutière
Fig. 17

Alpheus bradypus Coutière, Fauna and Geog. Mald. and Laccad. 2: 891, pl. 78, 79, fig. 30, 1905.

LOCALITY: Banner, 8 specimens in 1 collection, Saipan.

DISCUSSION: This group of eight specimens agree quite well with Coutière's description of his two damaged specimens. The most conspicuous differences between the two lie in the following characteristics: *1*, The second antennular article is slightly longer than that

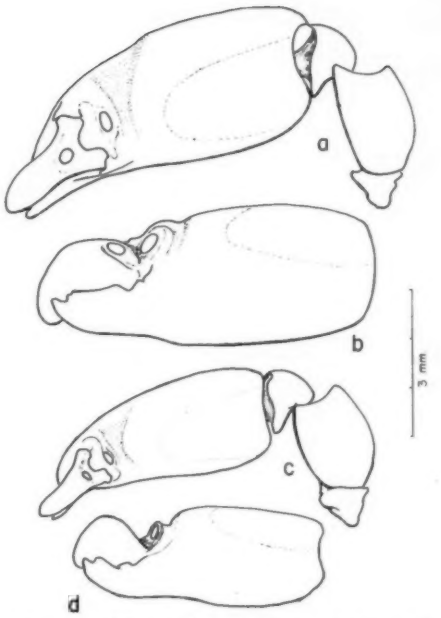

FIG. 17. *Alpheus bradypus* Coutière. *a*, *b*, large chela male; *c*, *d*, large chela, female.

described by Coutière. *2*, There is a small, poorly developed and difficult to discern tooth on the basicerite, while Coutière reported his specimens as unarmed. *3*, In none of the males did the dactylus of the small chela show the fringe of setae depicted by Coutière; moreover the small chelae of the males and females were more alike, showing less sexual dimorphism. *4*, The internal ramus of the uropods bears a row of numerous, although poorly developed denticles along its distal margin. These differences may in part be due to individual variation, so common in related species of this group, or they may be due to geographical variation; certainly it seems inadvisable at the present state of knowledge of the species to divide it into subspecies on the basis of these characteristics.

Both of Coutière's specimens were without the large chela. As most of these specimens are complete, I have shown the chelae of a mature male and a mature female in Figure

17. These chelae are dimorphic both in size and proportions. However, in both sexes there is a poorly demarked shallow depressed area on the upper side of the chela proximal to the articulation of the finger. This depression appears slightly more distinct in the female than in the male, possibly because the chela is more slender. The merus is unarmed on all margins but the inferior internal margin projects slightly distally.

There is some variation in the proportions of the antennular peduncle. The scaphocerite in one specimen, instead of reaching slightly past the middle of the third antennular article, reaches beyond it by half its length. In the same specimen the reduced squamous portion of the scaphocerite gradually tapers to its end which is opposite the distal end of the second antennular article instead of being more abruptly truncate opposite to the middle of the same article. Otherwise this specimen is similar to the others.

Alpheus eulimene de Man

Alpheus eulimene de Man, Siboga Exped. 39a[1] (2): 364; pl. 16, fig. 76, 1911.

LOCALITY: Cloud, 2 specimens at C-7a, 10 April 1949.

DISCUSSION: *A. eulimene* de Man and *A. styliceps* Coutière (1905: 889, pl. 78, fig. 28) are very closely related species, separated principally by the form of the frontal portion of the carapace and by the proportions of the third leg and the armature of the fourth. The two specimens from Saipan, a 9.0 mm. female and a broken and distorted male of 7.8 mm., lie somewhat intermediate between the two species. In *A. eulimene* the front of the carapace is almost straight in front of the orbital hoods, abruptly giving rise in the middle to a very short rostrum; it bears a dorsal carina that continues posteriorly to the middle of the carapace. In *A. styliceps* the anterior margin of the carapace curves gradually into a larger rostrum, but the carina does not extend posteriorly to the orbital hoods. In these specimens the rostrum is like *A. styliceps*, except that the curve is less gradual and the base of the rostrum more abrupt; the dorsal carina is like *A. eulimene*. In *A. eulimene* and in these specimens the merus of the third legs is slightly over 4 times as long as broad, while in *A. styliceps* it is only 3 times as long; in de Man's species and in these specimens the merus of the fourth leg is unarmed, while in Coutière's it bears a strong distal tooth. If the distinction between these species is maintained after more specimens are examined, then these two specimens appear to belong to de Man's species.

There are several further minor differences between these specimens and de Man's description. In the male the scaphocerites are asymmetrically developed, with that of the right being reduced as described by de Man, but that of the left better developed, with the tip of the lateral spine reaching beyond the end of the antennular peduncle and the squamous portion reaching to the middle of the third, not the second, antennular article. In the female the palm of the small chela is 1.9 times as long as broad and as long as the fingers, instead of 1.5 times as long as broad and longer than the fingers. Unfortunately the small chela is lacking in the male. De Man gives lengths for the articles of the carpus of the second leg which produce the ratio of 10:14.4 for the first two articles, yet his drawing shows a ratio of 10:17.5, more like these specimens (in the female they have the ratio of 10:18.5). Finally, in the dactylus of the third leg, de Man shows a uniform tapering curve, but these specimens have a rounded thickening two-thirds of the length distally, similar to that described for *A. gracilis* var. *simplex* (Banner, 1953: fig. 25k).

Alpheus pachychirus Stimpson

Alpheus pachychirus Stimpson, Acad. Nat. Sci. Phila., Proc. 12: 30, 1860.

LOCALITIES: Banner, 1 specimen; Cloud, 1 specimen at E-4, 3 at Loc. 9.

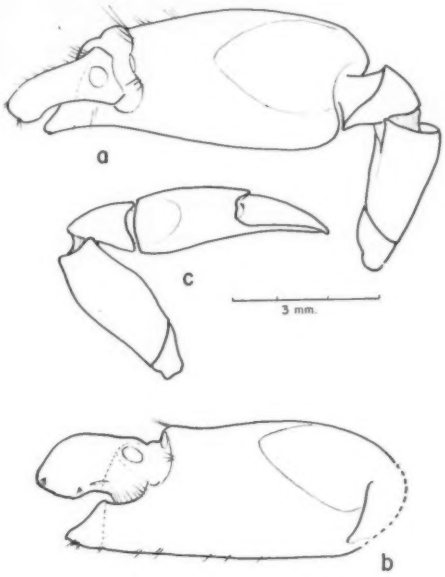

FIG. 18. *Alpheus ovaliceps* Coutière. *a*, *b*, Large chela; *c*, small chela.

Alpheus ovaliceps Coutière
Fig. 18

Alpheus ovaliceps Coutière, Fauna and Geog. Mald. and Laccad. 2(4): 888, pl. 77, fig. 27, 1905.

LOCALITY: Banner, 3 specimens, Saipan.

DISCUSSION: This species was described by Coutière on the basis of a single male from Minikoi. It has not been reported since then.

These three specimens, two males and a female, agree almost perfectly with the description and figures of Coutière, even to the two long and broadened bristles on the penultimate article of the third maxilliped. However, they do differ in two characteristics. In the Indian Ocean specimen the large chela had a marked taper towards the dactylar articulation and proximal to this articulation there was a slight transverse groove; in the present specimen, the chela maintains its full diameter throughout, and there is no such groove. The small chela is essentially similar in the two sets of specimens. (I have drawn the small cheliped of the female particularly to show the form of the merus, similar in both sexes.) Secondly, the outer spine of the uropod was reported by Coutière as being dark brown, whereas in these three specimens it is colorless.

Within this group variations are so common that no great significance is attached to these differences. Possibly if other specimens from the Indian Ocean are compared to these from the Western Pacific the differences would be found to intergrade; if they did not, at most they would justify the erection of a subspecies for the Pacific form.

Alpheus frontalis Milne-Edwards

Alpheus frontalis Milne-Edwards, Histoire Naturelle des Crustacés, 2: 356, 1837.

LOCALITY: Banner, 1 specimen, Saipan.

Diadema subgroup

Alpheus diadema Dana

Alpheus diadema Dana, U. S. Explor. Exped. 13: 555, pl. 35, fig. 7, 1852.

Alpheus insignis Heller, K. Akad. Wiss. Wien, Sitzungber. 44: 269, taf. 3, fig. 17–18, 1861.

Crangon diadema Banner, Pacific Sci. 7(1): 118, fig. 43, 1953. [Neotype established.]

LOCALITIES: Banner, 15 specimens in 3 collections; Cloud, 18 specimens at locality D-5, 1 at Loc. 8.

Alpheus gracilipes Stimpson

Alpheus gracilipes Stimpson, Acad. Nat. Sci. Phila., Proc. 12: 31, 1860.

Crangon gracilipes Banner, Pacific Sci. 7(1): 115, fig. 41, 1953.

LOCALITIES: Banner, 55 specimens from 8 collections; Cloud, 10 specimens at locality D-5, 2 at D-6.

DISCUSSION: The specimens of this species from Hawaii bear balaeniceps-shaped dactyli on the small chelae in both sexes; in these from Saipan, however, only the small chela

of the males is broadened and bears the characteristic fringe of setae. In the females the dactylus is slender, tapering uniformly to the acute tip, and lacking all traces of the fringe. Both sexes lack the slight transverse depression proximal to the dactylus.

It is likely that this is a separate subspecies, distinct from the form in Hawaii. However, the decision will be deferred until specimens are examined from other archipelagoes. When Tahitian specimens (the type locality) are examined it will be possible to decide, if a new name is to be applied, which form is similar to Stimpson's type.

Alpheus paracrinitus Meirs var. **bengalensis** Coutière

Alpheus paracrinitus var. *bengalensis* Coutière, Fauna and Geog. Mald. and Laccad. 2(4): 901, pl. 82, figs. 37–37a, 1905.

LOCALITIES: Banner, 17 specimens in 7 collections; Cloud, 1 specimen each at localities A-5, D-5, FX.

DISCUSSION: Variation is found in these specimens in the relative lengths of the antennular peduncle, the scaphocerite, and the carpocerite. In most the antennular peduncle does not reach to the tips of the other two, and most often the scaphocerite and the carpocerite are subequal. Only on a few specimens is the carpocerite considerably longer than the scaphocerite, as was commonly found in Hawaii (Banner, 1953: fig. 40a, b). In some specimens, on the other hand, the tips of the three parts reach essentially the same point. Variation is also found, as in Hawaii, in the armature of the merus of the large and small chela. In several specimens the fingers of the large chela are proportionately shorter, not more than about 0.2 the length of the chela; in other specimens the fingers of the small chela are much more hirsute. In all of the specimens the first and second articles of the second leg are subequal, the criterion for the separation of this variety from the parent species.

Brevirostris group

Alpheus rapax Fabricius

Alpheus rapax Fabricius, Sup. Ent. Syst., p. 405, 1798 [see de Man, 1909: 147–155 for synonymy].

LOCALITY: Guam, collected by Seale, 1900 (Bernice P. Bishop Mus. No. 161).

DISCUSSION: This sole specimen is definitely *A. rapax* as redescribed by de Man. The Hawaiian specimen of this species showed two differences from de Man's redescription: the merus of the small cheliped was lacking in a distal spine on the inferior internal margin, and the third legs were not densely hirsute. This specimen has a very small tooth on the merus, but, as in the Hawaiian specimen, the third legs bear only scattered setae.

Alpheus species 3
Fig. 19

LOCALITY: A 12 mm. male from Loc. 2, collected by P. E. Cloud, Jr.

DESCRIPTION: Rostrum acute, reaching about 0.7 length of visible portion of first antennular article, rostral triangle slightly longer than broad. Rostral carina strong, extending posteriorly half length of carapace. Orbital hoods inflated, rounded, similar in development to *A. rapax* Fab.

Second antennular article twice as long as broad, 1.3 times as long as first article, about 2 times as long as third. Stylocerite with acute lateral tooth projecting almost to end of first antennular article. Spine of basicerite of moderate development, relatively shorter than stylocerite. Scaphocerite with tip of lateral spine noticeably longer than antennular peduncle; spine exceeding flattened portion in length. Carpocerite slightly longer than scaphocerite.

Third maxillipeds, if extended straight, reaching beyond antennular peduncle. Last article 3.0 times as long as penulitimate and 4.0 times as long as broad.

Merus of large cheliped 2.8 times as long

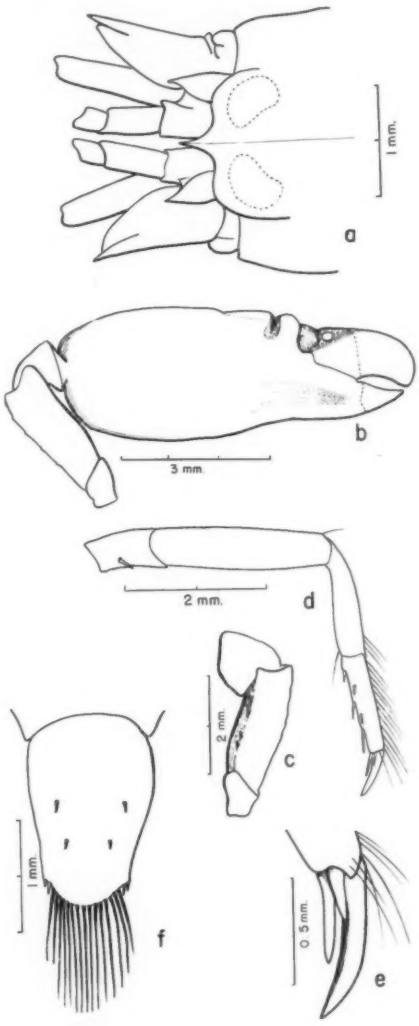

FIG. 19. *Alpheus* species 3. *a*, Anterior region, dorsal aspect; *b*, large chela; *c*, large cheliped, merus; *d*, third leg; *e*, third leg, dactylus; *f*, telson.

as broad, superior margin slightly irregular, inferior internal margin bearing four irregularly placed moveable spines. Chela 2.5 times as long as broad, with palm 1.85 times as long as fingers, with short transverse groove on superior margin, shallow depression on external face of base of fixed finger; chela with but few scattered setae.

Small cheliped and second legs lacking.

Ischium of third legs 0.3 as long as merus, bearing movable spine. Merus slightly over 4 times as long as broad, unarmed. Carpus half as long as merus, unarmed. Propodus tapering, as long as carpus, bearing five strong spines on or near inferior margin and two distally. Dactylus half as long as propodus, simple, curved, somewhat flattened on inferior margin. Distal end of carpus and entire propodus bearing long fine setae along superior margin.

Telson in specimen asymmetrical, 2.2 times as long as posterior margin is broad, anteriorly 1.4 times as broad as posteriorly; lateral margins anteriorly convex, posteriorly concave, with convexity of right side more pronounced than left; tip broadly arcuate. Dorsal and terminal spines of slight development.

DISCUSSION: It is unfortunate that this specimen is in such poor condition; in addition to lacking the small chela, both second legs, one of the third legs, both fourth legs and one of the fifth legs, the tissue within the exoskeleton is partially shrunken and withdrawn, leaving the exoskeleton without support; the exoskeleton, as a consequence, is difficult to discern and often distorted.

The form of the chela and the anterior carapace plainly places this species within the Brevirostris group. The groove of the chela, together with the keel on the carapace, the lack of a tooth on the merus of the third leg, and the narrowness of the same article serves to separate this species from all other species in the group except *A. brevirostris* (Olivier) and *A. savuensis* de Man. It is plainly different from the former in the scaphocerite, for in *A. brevirostris* the flattened portion reaches almost to the tip of the spine (de Man, 1909: fig. 15), and in the large chela, which appears much heavier in the palm and which has a dactylus that is about three times as heavy as the fixed finger (Coutière, 1899: fig. 281).

This form shows a closer relationship to *A. savuensis*, but can be separated from that species by a series of characteristics such as: the rostrum, which is shorter in *A. savuensis;* the rostral carina, which reaches only slightly past the orbital hoods; the stylocerite, which does not bear an acute tip like this form; slight (and possibly not significant) differences in the relative lengths of the antennular peduncle, scaphocerite and carpocerite; similar differences in the dactylus of the third legs, which de Man describes as not flattened, but which are slightly flattened on the inferior face in this specimen. In spite of these differences, which at best are minor, there appears to be much in common in general form between the two, especially in the large chela and third legs.

As the small chela and the second legs are so important in the separation of species in this genus and group, to say that this sole mutilated specimen is or is not the same as *A. savuensis* would be questionable. Likewise, if the specimen were considered as distinct from de Man's, little could be gained by the establishment of this defective specimen as a type for a new species.

Edwardsi group

Alpheus ladronis sp. nov.
Fig. 20

TYPES: Holotype, a 10.8 mm. male, collected by A. H. Banner, Saipan; allotype, a 13.0 mm. ovigerous female; paratype, a partially broken ovigerous female, same length; both females from same collection as male. Types to be deposited in the U. S. National Museum.

DESCRIPTION: Rostrum small, acute, reaching almost to middle of visible portion of first antennular article; lateral margins of base demarked from almost straight orbitorostral margins; sharp rostral carina extending to near posterior margin of eyes, continuing low and rounded, and soon merging with curvature of carapace; in lateral view carina higher than orbital hoods, depressed anteriorly. Orbital hoods relatively low, rounded, separated from carina by shallow rounded depressions.

Second antennular article 1.7 times as long as broad, 1.1 times as long as first, 1.5 times as long as third. Stylocerite reaching to end of first antennular article. Basicerite armed with small, acute tooth. Lateral spine of scaphocerite reaching to end of third antennular article, squamous portion almost as long. Carpocerite reaching slightly beyond end of scaphocerite.

Large chela compressed, 2.6 times as long as high, with fingers occupying the distal 0.3. Transverse groove proximal to dactylar articulation shallow and rounded, continuous on inner face as shallow rounded depression, U-shaped in outline, and on outer face as deeper, well-delimited groove extending proximally past middle of palm. Shoulder on inferior margin conspicuous, extending up both inner and outer faces. Dactylus and fixed finger with acute tips. Merus 0.3 as long as chela, with outer inferior margin rounded, superior distal margin slightly produced into a low, obtuse tooth, inferior internal margin bearing a strong tooth subterminally.

Carpus of second legs with ratio: 10:7:3:3:6.

Small chela 4.1 times as long as broad, fingers slender, tapering (not belaeniceps-shaped), occupying distal 0.6. Merus slender, unarmed.

Third legs with ischium unarmed; merus 4.6 times as long as broad, carpus 0.5 as long as merus, with superior margin continuing distally as rounded projection; propodus 0.77 as long as merus, armed along inferior margin with six relatively long, slender spines; dactylus simple, curved, slightly less than 0.3 as long as merus.

Telson 2.1 times as long as broad posteriorly, 1.6 times as broad anteriorly as posteriorly; margins rounded, with arcuate posterior margin a continuation of curved lateral margins. Dorsal spinules on type asymmetrical, as shown in Figure 20*i*. Lateral spine

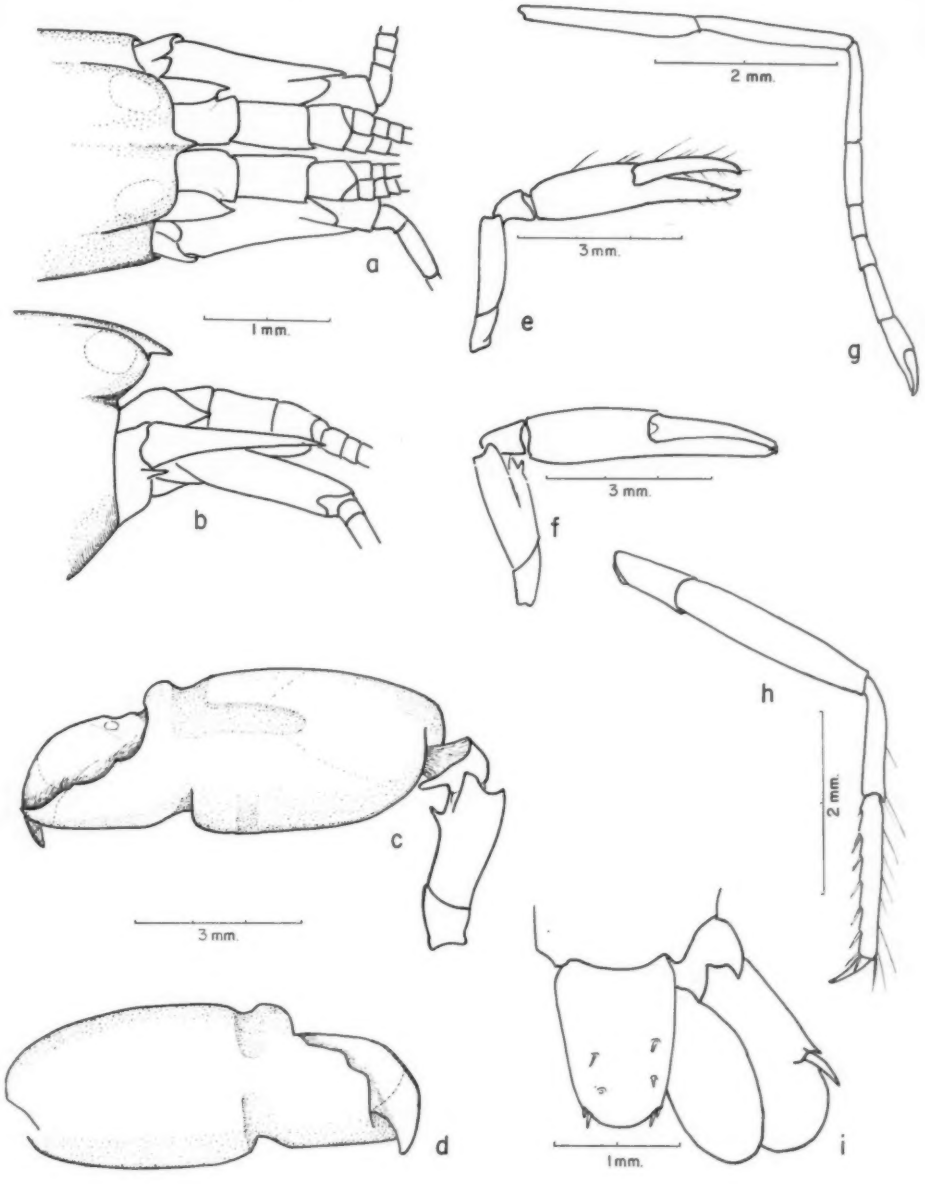

FIG. 20. *Alpheus ladronis* sp. nov. *a*, *b*, Anterior region, dorsal and lateral aspects; *c*, *d*, large chela, lateral and medial aspects; *e*, small cheliped, male (type); *f*, small cheliped, female (allotype–setae not shown); *g*, second leg; *h*, third leg; *i*, uropods and telson.

of outer uropod strong but exceeded by distal curved margin.

DISCUSSION: The two paratypes differ in two important ways from the type: in both the merus of the small chela carries a tooth similar to that of the large cheliped, and in both the margins of the telson are less rounded, with a more pronounced taper in the posterior half (in one the anterior margin is 1.9, in the other 3.0, times the breadth posteriorly). Other lesser differences were noted in the fingers of the large chela, which are more rounded, in slight difference in proportions in the carpus of the second legs, and in the uropods, which do not protrude as far beyond the lateral spine. It is likely that the difference in the fingers of the large chela, and it is possible that difference in the armature of the merus of the small chela, are secondary sexual characteristics; the other differences probably are normal variation.

This species plainly belongs to the Edwardsii group, and within that group appears to be most closely related to *A. bouvieri* A. Milne-Edwards and *A. bastardi* Coutière. From the latter it differs in the form of the rostrum, the more slender form of the small cheliped, and, if a specimen from Yap to be reported in a later publication is the same as Coutière's species, in the presence of the meral spines of the large chela and the absence of ischial spines of the third legs. From *A. bouvieri* it differs most notably in the absence of sexual dimorphism in the small chela; it apparently also differs in the presence of teeth on the basicerite and the merus of the large chela. Unfortunately, complete descriptions are not available for either of the species and it is possible that *ladronis* will be found either to be more closely related or more widely separated when the types are compared.

The specific name is derived from Magellan's name for the Mariana Islands.

Alpheus pacificus Dana

Alpheus pacificus Dana, U. S. Explor. Exped. 13: 544, pl. 34, fig. 5, 1852.

Crangon pacifica Banner, Pacific Sci. 7(1): 138, fig. 50. [Neotype established.]

LOCALITY: Banner, 2 specimens from one locality, Saipan.

DISCUSSION: Although these specimens are small and immature, they compare well to specimens of similar size from Hawaii. It is notable that in the large collection of specimens from Saipan only two specimens of this species were found, yet it is one of the most common in Hawaii.

Alpheus leptochirus Coutière

Alpheus leptochirus Coutière, Fauna and Geog. Mald. and Laccad. 2(4): 914–916, pl. 87, fig. 54, 1905.

SPECIMEN: Banner, a single specimen, Saipan.

DISCUSSION: This sole specimen, a male, is very similar to the female reported from Hawaii (Banner, 1953: 133, fig. 48) in all characteristics, and in those points where the Hawaiian specimen differs from the type, it is more similar to the Hawaiian specimen than to the type, except that in the first two carpal articles of the second leg the ratio is 10:9, intermediate between the ratio of 10:11 in the Hawaiian specimen and 10:7 in the type. Another slight point of difference is in the armature of the merus of the small and large chelae, which, instead of bearing movable spines as did the previous forms, bear short stiff setae.

Alpheus dolerus sp. nov.
Fig. 21

TYPES: Holotype, a 17.0 mm. male collected on Saipan in 1944 by A. H. Banner; allotype, a 14.6 ovigerous female from the same collection; paratypes, 12 specimens in 6 collections by A. H. Banner; 1 specimen from Loc. 6, collected by P. E. Cloud, Jr.

DESCRIPTION: Rostrum acute, reaching to end of first antennular article, continued posteriorly to slightly behind corneas as low

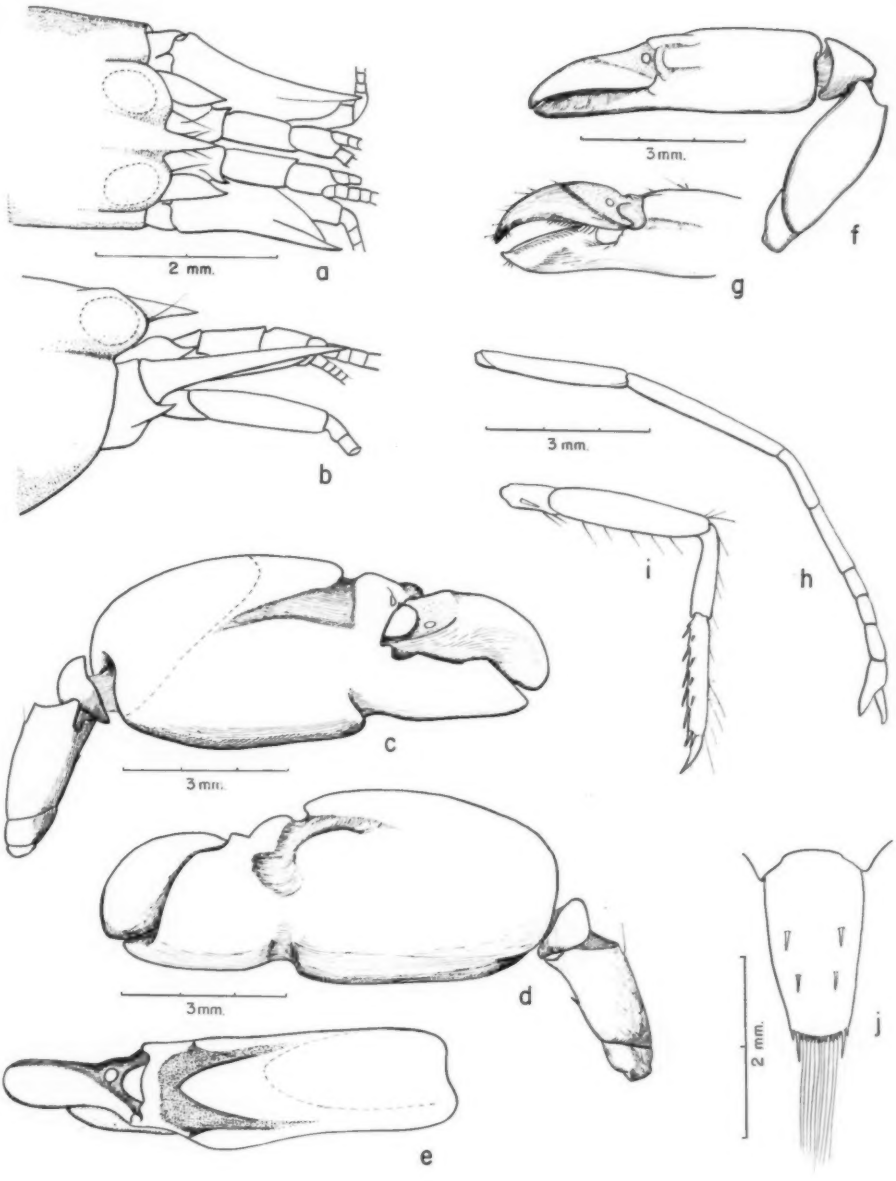

FIG. 21. *Alpheus dolerus* sp. nov. *a*, *b*, Anterior region, dorsal and lateral aspects; *c*, *d*, *e*, large chela, lateral, medial and dorsal aspects; *f*, *g*, small chela; *h*, second leg; *i*, fourth leg; *j*, telson.

rounded ridge; lateral margins bearing two stiff setae. Orbital hoods rounded, slightly inflated; orbitorostral area depressed, shallow, rounded.

Second antennular article twice as long as broad, slightly longer than first and third articles; lateral spine of stylocerite reaching to end of first antennular article. Lateral spine of basicerite small but acute; tip of spine of scaphocerite reaching beyond end of antennular peduncle; squamous portion of scaphocerite narrow, reaching to end of antennular peduncle; carpocerite slightly shorter than scaphocerite.

Large chela compressed, massive, 2.6 times as long as broad, with fingers occupying distal third. Palm with sculpturing common for group, superior transverse groove continuous with triangular depressed areas on either face; proximal margin of groove, when seen in profile, vertical to margin of palm. Inferior lobe slightly distal to superior groove, strong, and continuing to 0.25 height of palm on outer face; rounded on inner face. Dactylus heavy, compressed, superior margin rounded. Length of merus equal to about 0.5 height of palm, outer face less than 2.5 times as long as broad; inferior internal margin sharp, bearing single movable spine in middle, and distally produced into strong, acute tooth.

Small chela 3.2 times as long as broad, with fingers occupying distal 0.5; palm proximal to adhesive plaque slightly raised, rounded, with shallow depressions on either side; no teeth about digital articulation. Dactylus slender, tapering and curved, with slight trace of setiferous expansion on proximal portion; inner face bearing knife-like ridge that meets corresponding ridge on fixed finger; knife ridges of both fingers paralleled by row of short stiff setae. Merus half as long as chela, slightly over twice as long as broad, bearing movable spine and distal tooth like that of large cheliped on inferior internal margin.

Carpus of second legs with ratio: 10:11: 4.2:4.5:5.8.

Ischium of third legs bearing strong movable spine; merus 4.3 times as long as broad, distally unarmed; carpus 0.5 length of merus, superior and inferior margins produced but rounded; propodus 0.7 as long as merus, bearing five strong spines on inferior margin, five smaller spines near margin, two strong spines distally. Dactylus simple, tapering, curved, 0.25 length of merus.

Telson 3.3 times as long as tip is broad, 1.8 times as broad anteriorly as posteriorly; lateral margins slightly concave in posterior third; tip broadly arcuate, larger spines about half as long as tip is broad, tip also bearing series of short spinules above bases of setose bristles; anterior pair of dorsal spines before middle.

Paratype similar to holotype in all characteristics except that length of merus of large chela is approximately equal to height of palm and relatively more slender.

DISCUSSION: The specimens in the paratypic series exhibit the normal and expected variations. In some, especially the smaller specimens, the rostrum is shorter, in one extreme case reaching only to the middle of the visible portion of the first antennular article. On the meri of both chelae the number of spines is variable, from none (especially on the smaller cheliped) to three; in one specimen, of questionable identity because it was small and broken, there are eight movable spines. The large chela itself often is somewhat more slender, in one reaching the maximum of 3.0 times as long as broad. In several specimens the tips of the fingers are calcified and white. The relative lengths of the spines on the propodus of the third legs are also variable, some being shorter and others being longer than those depicted for the type specimen. In the telson of many specimens the margins of the anterior portions are straighter and more parallel, posteriorly the margins are more deeply concave, the tip is relatively narrower.

In one female from the collection that produced the type and allotype the setae, but not the spines, of the telson, uropods and

posterior pleopods were dark, almost black, contrasting with the alcohol-bleached body.

This species plainly belongs to the Edwardsii group of the genus, and can be separated from most other members of the group by the form of the rostrum, the lack of a meral tooth, the simple dactylus of the third legs, and the simple condition of the dactylus of the small chela in both sexes. In the key of de Man (1909: 325) this species comes out to *A. haanii* Ortmann, but the two species cannot be confused because *haanii* bears deep grooves arising both medially and laterally to the orbital hoods that almost encircle the orbital hoods according to de Man's redescription of the type specimen (1897: 751); moreover, the second carpal article is definitely shorter than the first (ratio of 2.3:1.5 instead of 10:11).

This species looks very similar to the specimens which I identify as *A. leptochirus* Coutière. If it were not for the lack of the fringe of setae on the dactylus of the small chela of the male, the two would have been considered to be a single species. In fact, the great similarity renders questionable the use of this fringe of setae as a specific characteristic. However, as there is no evidence, only suspicions, about the validity of this accepted criterion, it was decided to describe this species as new.

The name is derived from the Greek doleros —deceptive.

Alpheus parvirostris Dana

Alpheus parvirostris Dana, U. S. Explor. Exped. 13: 551, pl. 35, fig. 3, 1852.

LOCALITIES: Banner, 65 specimens in 9 collections; Cloud, 2 specimens at A-5, 1 at C-7a, 6 at D-5, 2 at Loc. 6.

DISCUSSION: These specimens agree very well with the redescription given by de Man (1911: 432) and with the short original description. There are several minor but noteworthy variations, however. De Man stated that the length of the first carpal article of the second legs was about twice the length of the second article, whereas in most of these specimens it ranges from 1.5 to 1.8 times as long. The tooth on the inferior margin of the third and fourth legs varies in its development, with that of the fourth legs at times lacking, and that of the third legs quite small; this variation appears to be roughly correlated with size, with the smaller specimens showing a poorer development of the meral tooth. Like de Man's specimens, these specimens showed variation in the relative lengths of the stylocerite, scaphocerite and especially the lateral spine of the basicerite.

Coutière's statement of distribution for this species (1905: 906), that it is found "depuis le cap jusq'aux îles Sandwich. . . ." is not based on any other published record, and the species was not found in the extensive Hawaiian collections previously reported upon (Banner, 1953). It is likely the statement is erroneous.

THUNOR

In 1949 Armstrong (1949: 12) erected a new genus *Thunor* for the species described by Schmitt as *Crangon rathbunae* (1924: 74) from the Barbados. He separated *Thunor* from *Alpheus* (*Crangon*) primarily on the basis of four characteristics: *1*, The obsolesence of the ocular beak, the anterior projection arising between the bases of the eye stalks. *2*, The absence of the cardiac notch, a notch on the posterior margin of the carapace between the attached dorsal region and the bases of the branchiostegites. *3*, The lack of anal tubercles, projections on the ventral side of the telson flanking the anus and engaging the inner uropods. *4*, The absence of a transverse articulation on the outer uropod. There were also two other characteristics that Armstrong evidently considered as less important: The rostrum was absent and the outer branch of the palp of the first maxilla lacked setae. Otherwise the genus was like *Alpheus* with the large chela like that of the Obesomanus group; moreover, the type species, *T. rath-*

bunae has an elongation of the antennular peduncle and the extreme reduction of the parts of the antennal base that is also common in the Obesomanus group. Armstrong felt that *T. rathbunae* was most closely related to *A. idiocheles* Coutière (printed *idocheles, lapsus calumi*), an unusual species that Coutière placed in the Megacheles group with doubts. These two species are closely related; as I am tentatively accepting *Thunor* I am transferring the species *idiocheles* to this genus and adding another species here referred to as *T.* species 1

To review the validity of this separation I have examined specimens that I consider to be related to *T. rathbunae*, to *T. idiocheles* or to the Obesomanus group. These include specimens identified as *T. idiocheles*, *A. lutini* Coutière, *A. microstylus* (Bate), *A. phrygianus* Coutière, *A. perplexus* and *A. chamorro* and three specimens, possibly belonging to new species, too incomplete for specific identification, *A.* species 2, and *T.* species 1. The characteristics of these species are discussed in their individual sections; here only the way they meet the criteria of Armstrong is considered.

1. The ocular beak. As this characteristic is impossible to see unless the specimen is either distorted in capture or the intact specimen torn apart, I do not feel inclined to ruin one of the small number of specimens representing some species. The character was not examined in *A. lutini*, *A. perplexus*, *A. chamorro*, and *A.* species 2, in the others it is as follows:

T. idiocheles and *T.* species 1—lacking.

A. microstylus—present but poorly developed.

A. phrygianus—present, of moderate development.

2. The cardiac notch. In most specimens this characteristic is difficult to discern because the posterior margin of the carapace is not well defined, and, being transparent, tends to be indistinguishable from the opaque white of the underlying tissues.

T. idiocheles, *A. lutini*, *microstylus*, and *chamorro*—cardiac notch present.

A. phrygianus—cardiac notch lacking, but dorsal region set off from brachiostegites by an angle.

A. species 2—region rounded where cardiac notch should occur.

T. species 1—slightly developed cardiac notch in male, margin without notch but angular, not rounded, in female.

3. The anal tubercles. In those species in which they are present, they are well developed in the form of a small papillose structure; otherwise there is no vestige of them.

T. idiocheles, *T.* species 1—lacking anal tubercles.

A. lutini, *microstylus*, *phrygianus*, *perplexus*, *chamorro*, and *A.* species 2—anal tubercles present.

4. Articulation of the outer uropod. Often this is difficult to see in preserved specimens. It can best be checked by bending the tip of the uropod ventrally and noting whether it bows in a rounded fashion or bends sharply along the line of articulation.

T. idiocheles, *T.* species 1—without articulation.

A. lutini, *microstylus*, *phrygianus*, *perplexus*, *chamorro*, and *A.* species 2—with articulation.

In this series of species, e.g., *A.* species 2 and *T.* species 1, as well as those previously reported, e.g., *A. microstylus*, the presence or absence of the rostrum is variable within the species. In no specimens were the maxillae examined.

To recapitulate Armstrong's criteria: the ocular beak as the basis for working separation appears to be valid but impractical, especially where only a few specimens are available; the cardiac notch appears to be too variable; leaving for the separation of the two genera only the two characteristics, the anal tubercles and articulation of the uropods. If this separation is made, then *T. idiocheles*, and *T.* species 1 belong to *Thunor*.

Opposed to this separation would be a series of characteristics, for the species agree well with *Alpheus* for the most part. The ex-

treme form of the rostral front of *T. rathbunae* is approached in a number of species plainly belonging to *Alpheus* (including *A.* species 2); the peculiar development of the antennules and antennae is approached by many species of the Obesomanus group; the large and small chelae are similar to those found in the Obesomanus group; there is nothing in the second and subsequent thoracic legs and pleopods that would serve to separate the two genera; even the brachial formula is the same.

I, therefore, am in doubt as to the validity of this separation, and believe that at most the species of *Thunor* should be put into a group or subgroup within the genus *Alpheus*. However, until more closely related species are examined in reference to these differences and similarities in order to better determine the constancy of the differences, I will recognize the genus *Thunor*.

Thunor idiocheles (Coutière)
Fig. 22

Alpheus idiocheles Coutière, Fauna and Geog. Mald. and Laccad. 2(4): 883, pl. 75, fig. 21, 1905.

LOCALITIES: Banner, 5 specimens in 4 collections; Cloud, 1 specimen at locality D-7.

DISCUSSION: These specimens agree very well in almost all characteristics with those in Coutière's description. However, there are some variations that should be noted. The rostrum is found to vary slightly in proportions, from a slight triangle to one that reaches as far anteriorly as the rounded anterior end of the stylocerite. In all specimens the rostral carina is marked. The carpocerite and lateral spine of the scaphocerite in one specimen are equal in length to each other and reach only to the end of the second third of the second article of the antennular peduncle, in other specimens they are unequal with the carpocerite only reaching to the end of the second antennular article, and in one specimen the spine of the scaphocerite reaches to the end of the second antennular article and the carpocerite exceeds it, reaching almost a third the length of the third antennular article. Of the four specimens which retain a large chela, three have a length-breadth ratio of 3, instead of 3.5 as reported by Coutière. The telsons are quite variable, and in none were the posterolateral spines as poorly developed as those shown by Coutière. Finally, four of the six specimens have a strong brown spine on the external margin of the outer uropod; the other two have more slight and colorless spines; in none are there two short brown spines as described by Coutière.

Two of the specimens have such markedly dissimilar telsons that they were originally thought to be of a different species. These are the specimens illustrated in the figures. Unfortunately neither specimen has its large chela intact. However, as they agree very well otherwise with intact specimens identified as this species, and as the telsons of the four intact specimens are also variable, it is thought that this difference probably is not of significance. Similar wide variation has been reported by Armstrong in *Thunor rathbunae* (Schmitt).

Coutière did not remark upon the lack of an articulation in the outer uropod, and, to the contrary, he showed a line that could be interpreted as an articulation in his figures. None of the Saipan specimens has an articulation although some show a slight line starting transversely from the region of the lateral spine, similar to that shown by Coutière. This faint line, possibly a rudimentary articulation, does not reach to the opposite margin in any specimen.

The cardiac notch of the carapace is present and the anal tubercles are lacking in all specimens.

Thunor species 1
Fig. 23

SPECIMENS: An 8.5 mm. male (carapace length 3.7 mm.) lacking large and small chelae, and one of each pair of posterior

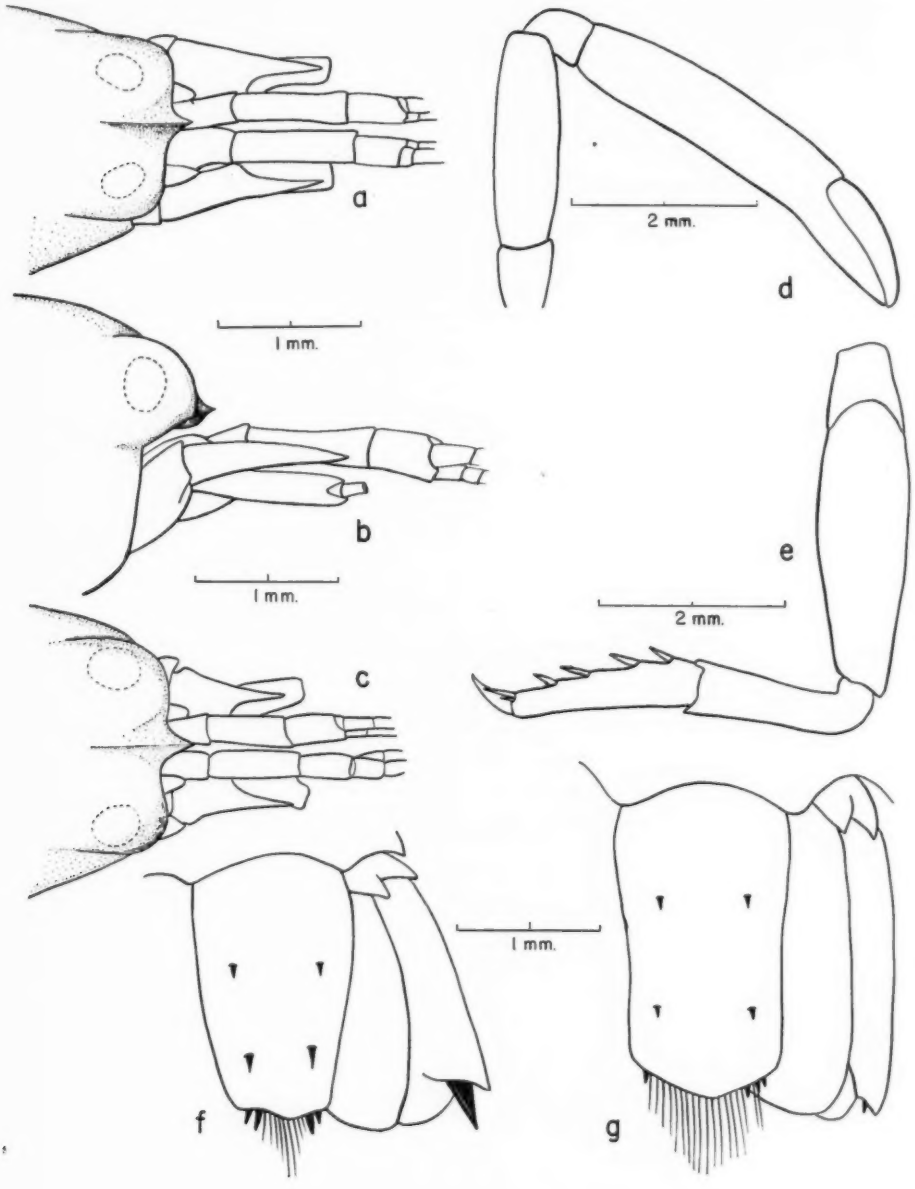

FIG. 22. *Thunor idiocheles* (Coutière), aberrant specimens. *a*, *b*. Anterior region, dorsal and lateral aspects, male; *c*, same, female; *d*, small cheliped, female; *e*, third leg, male; *f*, telson and uropod, male; *g*, telson and uropod, female.

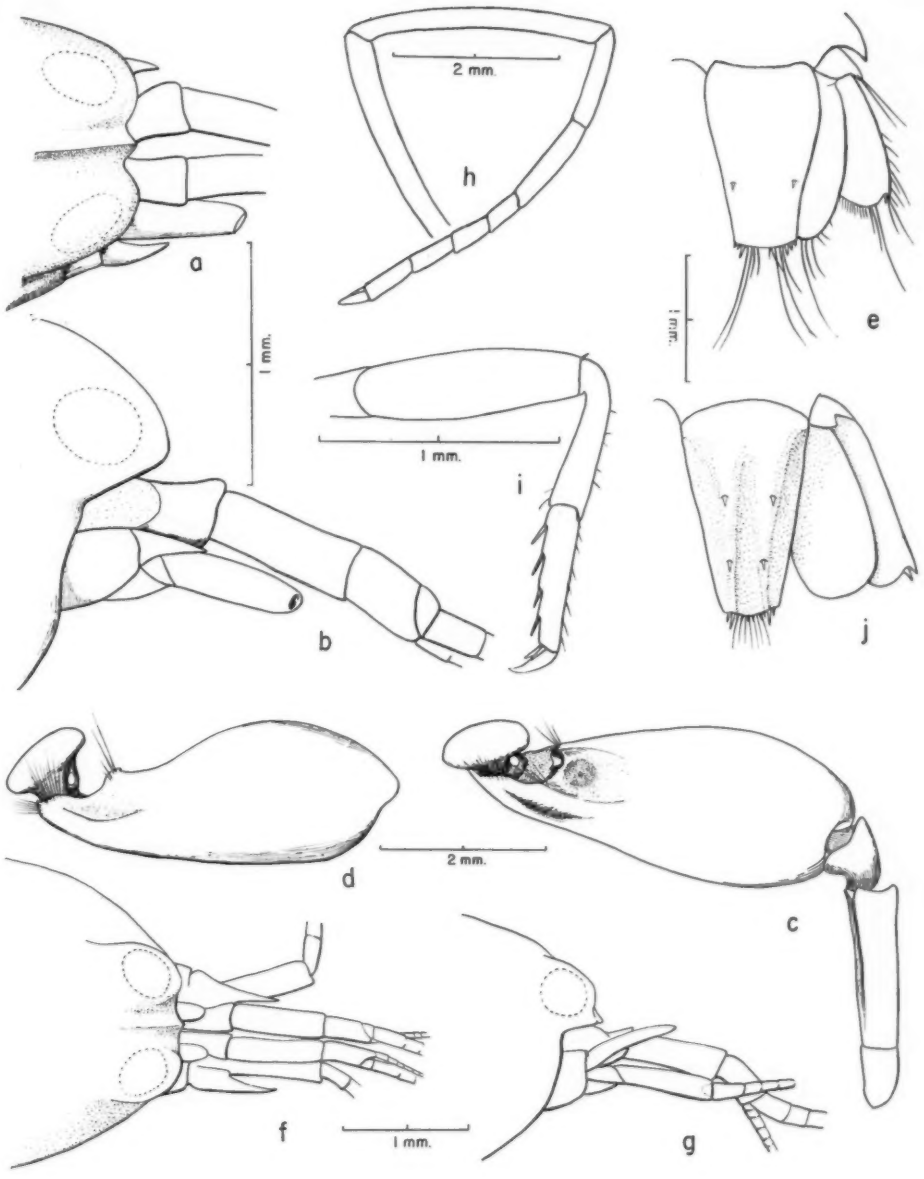

FIG. 23. *Thunor* species 1. *a–e*, Female: *a*, *b*, anterior region, dorsal and lateral aspects; *c*, *d*, large cheliped; *e*, telson and uropod. *f–j*, Male: *f*, *g*, anterior region, dorsal and lateral aspects; *h*, second leg; *i*, third leg; *j*, telson and uropod.

thoracic legs; a 10.4 ovigerous female (carapace length 3.9 mm.) lacking all thoracic legs except the large chela, basal articles of 2nd and 4th legs, and 5th legs. Specimens collected at the same time by A. H. Banner.

DESCRIPTION: Body heavy, with cephalothorax markedly heavier than abdomen; thoracic legs long and heavy. (Because of the differences between the male and the female the descriptions will be given separately.)

Male. Anterior carapace rounded and depressed in lateral view. Orbital hoods inflated, rounded anteriorly, and higher in lateral view than interorbital area. Rostrum small, triangular, acute, and bearing a low but sharp carina that extends posteriorly to behind orbital hoods. Margin of carapace between anterior orbital hoods and rostrum almost straight.

Antennular peduncle long and slender, with second article 4 times as long as broad and about twice as long as visible portion of first and third articles (third article slightly longer than first). Stylocerite rounded, reaching only 0.5 length of visible portion of first article. Outer flagellum 1.1 times as long as peduncle, inner flagellum slightly longer than outer.

Basicerite unarmed. Scaphocerite reduced, with tip of lateral spine reaching only to middle of second antennular article; blade almost rudimentary, reaching only to end of first antennular article. Carpocerite reaching end of second antennular article. Flagellum long, about 2.5 times as long as outer antennular flagellum.

Carpal articles of second legs with the ratio: 10:12:4.5:5.2:6.0. Chela as long as basal carpal article, with fingers occupying only distal 0.3.

Third legs with ischium unarmed. Merus unarmed, 3.5 times as long as broad. Carpus with superior distal margin projecting as a heavy rounded tooth, inferior margin unarmed; 0.57 as long as merus. Propodus 0.64 length of merus, 4 times as long as broad proximally, and tapering distally; armed with four strong spines on inferior margin and two distally. Dactylus simple, curved, slightly less than 0.3 the length of propodus.

Pleura of anterior abdominal somites rounded. Uropods of usual form and armature except strong spine of outer uropod brown and outer uropod without trace of distal articulation. Telson 4.0 times as long as posterior margin is broad, 2.5 times as broad anteriorly as posteriorly; lateral margins almost straight, posterior lateral corners rounded, posterior margin slightly arcuate. Anterior pair of spinules 0.4, posterior pair 0.7 of length of telson posterior of articulation; posterior lateral pairs of spinules of moderate development; central tuft of setae of usual form but short, and telson bearing at bases of setae a series of short spinules. Dorsal surface of telson without usual uniform convexity, but bearing two low rounded ridges that merge anteriorly.

Female. Orbital hoods similar in form to those of male. Rostrum slightly asymmetrical, rounded; dorsal carina higher and more rounded than in male. Margin of carapace between orbital hoods and rostrum not straight but with rounded and asymmetrical indentations.

Antennular peduncle similar to that of male except stylocerite concealed by carapace in dorsal view. Flagellar lengths about same as in male.

Basicerite unarmed, rounded. Scaphocerite extremely reduced, a simple, heavy, acute triangle, with tip reaching almost to end of first antennular article. Carpocerite reaching only slightly past middle of second antennular article. Flagella broken.

Large chela slightly compressed at base, with rounded margins; 2.7 times as long as greatest width, strongly tapering towards fingers. Dactylus hammer-shaped, with length of "head" about 0.2 length of entire chela. Fixed finger rounded, hardly extending beyond articulation of dactylus, much shorter than dactylus and not meeting in apposition. Palm of large chela with two rounded ridges distally leading towards palmar adhesive plaque; adhesive plaque borne on eminence

that is proximally delimited by deep, rounded concavity that accommodates end of "head" of dactylus when dactylus is flexed. Palm also bearing shallow, triangular depression or groove near dactylar articulation; corresponding area on inner face marked by much less extensive depression. Merus of cheliped 4 times as long as outer face is broad, unarmed.

Outer uropod short, abruptly truncate; spine at termination of outer shoulder poorly developed; ramus with small distal triangle that appears to have resulted from a fracture, not an articulation; tip bearing only few long setae. Inner uropod of usual form but with only occassional long setae. Telson 2.9 times as long as tip is broad, 1.8 times as broad anteriorly as posteriorly; lateral margins anteriorly convex, posteriorly slightly concave, slightly asymmetrical; posterior lateral corners rounded; tip very slightly arcuate; superior surface smooth, armed with but a single pair of spines of feeble development located 0.7 of the length posterior to articulation; on tip three pairs of spines and two pair only of long setae adjacent to spines, three shorter setae on left, two on right, middle of tip devoid of all setae.

Eggs without developing larvae, subspherical, 0.6 mm. diameter.

DISCUSSION: These two fragmentary specimens are perplexing. The question arises as to whether they are of the same species. The general form of the anterior carapace, the antennules, the few appendages that they have in common, are similar, yet there are marked differences in the rostrum, in the scaphocerite and especially in the telson and uropods. Unfortunately, because of the fragmentary condition of the specimens, comparison cannot be made in the thoracic legs. In view of the considerable variation that has been noted in the species of *Thunor* and in related Obesomanus group of the genus *Alpheus*, in view of the general similarities noted, and especially in view of the fact that this pair, male and female, were collected together and may have been therefore a cohabiting pair, I believe that they represent a single species and their differences are individual variations.

The lack of anal tubercles and the lack of the articulation on the outer uropod place this species in the genus *Thunor*. These two fragmentary specimens can be distinguished from *T. idiocheles* (Coutière) in the proportions of the antennular peduncle, the greater reduction of the scaphocerite and, most important, in the depression on the palm of the large chela behind the dactylar articulation and the pronounced hammer-shape of the dactylus of this appendage. This species can be distinguished from the Caribbean *T. rathbunae* by the presence of a rostrum. Another specimen of this species, more complete, is available in another collection, and with that as the type the species will be described and named in a later paper.

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[3] In my 1953 paper (p. 1) I noted that Haskell, in his study of the reports of the U. S. Exploring Expedition, considered that February, 1853, was the official date of publication of Dana's volume on the Crustacea. L. B. Holthius has pointed out to me in a personal communication that this is only the date that the U. S. Printing Office delivered 58 official copies of the work to the Department of State, and that the unofficial copies must have been distributed earlier, for the *American Journal of Science* (Ser. 2, 15: 466, 1853) acknowledges the receipt of this volume in December, 1852. Therefore the generally accepted date of publication, 1852, is the correct one.

Dr. Holthius also pointed out that the part of volume 6 of the proceedings of the Academy of Natural Sciences, Philadelphia, that carries Dana's "Conspectus Crustaceorum etc.", and which bears the volume date of 1854, must have been published by May, 1852 (*op. cit.* 6(3): 71, 72), so for questions of priority for Dana's species, this earlier date should be used.

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